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Supplementary Report on Helium - An Analysis of the Study Topics Suggested by the Interagency Helium Committee

Office of Minerals Policy and
Research Analysis

U.S. Department of the Interior

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Introduction

On March 10, 1978, the Secretary of the Interior transmitted an Interagency Helium Study to the Chairmen of the House Committee on Appropriations, the Senate Committee on Appropriations, the Senate Committee on Energy and Natural Resources, and the House Committee on Interior and Insular Affairs. That report was requested by the House Committee on Appropriations in Report No. 95-392 on H.R. 7636, Department of the Interior and Related Agencies Appropriations Bill for 1978. In Report No. 95-76, the Senate concurred with the House report.

The Interagency Helium Study discusses the basis for the Federal helium program, considers possible demand scenarios to the year 2030, and contains a number of suggestions presented as a recommendation for further study. These study topics are:

1. As a possible overall policy, determine the conservation and fiscal implications of amending the Helium Act to provide for helium management by the Federal Government for national needs rather than strictly Federal Government needs.

2. Determine the effects of amending the Helium Act of 1960 to permit Federal agencies to purchase helium from the private sector. Government helium sales might be phased out over a period of time sufficient to allow private industry to increase production capacity to supply both Federal and private markets. The helium in storage at the Cliffside field might then be treated as a national helium reserve, with its use restricted to national security, national emergency (such as war), or to fulfill important unmet long term national needs.

3. Determine the feasibility and costs of (a) cancelling the outstanding helium debt, and (b) financing or supplementing the finances of the program by annual appropriations if Federal helium sales were to be discontinued.

4. Evaluate the desirability of policies which might be used to encourage extraction and storage of helium from fuel (high-Btu) gas, including the effectiveness of low storage fees, ready return, or other incentives for encouraging the storage of privately owned helium at the Cliffside reservoir. This might include examining the feasibility

and costs of encouraging the conservation of helium by the private sector through amendments to the Internal Revenue Code to (a) permit the cost of helium extraction and transportation for conservation and storage to be deducted as an expense for the year in which such expense is incurred, and (b) recapture such deductions at the time the helium is sold.

5. Appraise on a regular basis the role of the Keyes plant and other Government helium properties in meeting the national needs for pure helium production. One issue might be utilization of the Keyes plant to supplement private production as needed if Government helium sales were to be phased out.

6. Review the legislated authority of the Secretary of the Interior to establish or continue policies that reserve or recover the helium from nondepleting and depleting reserves on Federal lands.

7. Assess existing technology to determine the advantages of and to set priorities for possible basic research, including the following:

   (a) Economic processes for recovering helium from gases with lean helium contents,

   (b) helium recovery from industrial gas production and LNG plants,

   (c) helium recovery from the atmosphere, and

   (d) technologies that conserve helium.

8. Consider having the Department of the Interior jointly examine with major Federal users (currently DOD, NASA, and DOE) any important changes in the status of the Nation's helium supply/demand situation, at least every 5 years.

This follow-up report by the Department of the Interior is supplementary to the interagency report and provides a discussion and evaluation of some of the resource implications of the above study

topics. Three alternative program levels are considered in this report; a business-as-usual base case, a phase-out of Bureau of Mines sales, and a phase-out of Bureau of Mines sales combined with the shut down of the Bureau's Keyes field helium extraction facility.

No attempt is made to consider actions beyond those identified in the recommendations. The U.S. Government is a defendant (or intervenor) in nine helium lawsuits. Five of these involve disputes over the ownership and value of helium extracted from natural gas and sold to the government. The remaining suits were brought against the government by helium contractors to recover damages for alleged breach of contract. Until this litigation is resolved, some of the alternatives not discussed in the interagency report, such as additional purchases or storage in an "escrow" account are not feasible.

The business-as-usual scenario in which Federal demand continues to be supplied by the Bureau of Mines to the year 2000 is used as the base case to which alternatives are compared. The calculations are not carried into the 21st century because estimates of demand, supply, costs, and Treasury receipts or outlays beyond a 20- to 25-year time horizon give the appearance of precision to a projection which is highly speculative. But since some possible major uses for helium may not occur until well into the 21st century, the estimated cumulative demand to the year 2000 used in this report may be an uncertain guide to potential demand later on.

No new resource or demand estimates have been made for this study. This report uses the intermediate demand estimate developed for the Interagency Helium Report. Although the most probable helium demand scenario, as identified in the Interagency Report, lies between the low and intermediate demand schedules, these schedules differ little through the year 2000.

In essence, the crux of the "helium problem" is an intergenerational transfer, i.e., whether the present generation is willing to invest current resources in a substance with unique features and conserve this substance for future generations, when neither the timing nor the magnitude of future needs can be established with any certainty. The matter is complicated in that low-cost helium (very high-cost helium will always be available from the atmosphere) is a coproduct of natural gas production and thus will be produced along with natural gas in large quantities during the next few decades, irrespective of demand or conservation decisions.

Also included in this report is a discussion of recent developments regarding the Tip Top Field in Wyoming, a so called nondepleting gas field, about 95% of which is Federally owned. After submission of the Interagency Helium Report by the Interagency Committee, the operator of the field announced plans to drill wells into the helium-rich zones and start natural gas production in the early 1980's. According to a preliminary resource estimate, this field contains nearly 45 billion cubic feet of helium, enough to supply current U.S. consumption for 50 years. Since the helium on Federal lands is owned by the Federal Government (a provision in the 1920 Leasing Act) a decision will have to be made concerning the disposition of the helium that will be produced with the natural gas as a coproduct. Firm Departmental program commitments for Tip Top are probably not necessary at this time, given the scheduled slow pace of development and the uncertain natural gas resources available.

Management for National Needs

(Study Topic 1 as amplified in the last sentence of Study Topic 2)

> As a possible overall policy, determine the conservation and fiscal implications of amending the Helium Act to provide for helium management by the Federal Government for national needs rather than strictly Federal Government needs.
>
> The helium in storage at the Cliffside Field might then be treated as a national helium reserve, with its use restricted to national security, national emergency (such as war), or to fulfill important unmet long-term national needs.

Providing for national needs implies a broader point of view than providing for Federal needs. More than the foreseeable needs of the various government agencies that consume helium would be considered. It seems unlikely that, within the next 20-25 years, national needs requiring large amounts of helium could arise that would be described as a national emergency or national security program. The most likely event would seem to be a major technological breakthrough which could be implemented in a relatively short period of time - less than 10 years - resulting in helium requirements that could not be supplied through the private market. Since helium extraction and purification plants can be constructed within 2 years assuming no delays due to environmental difficulties, these requirements would have to be substantial. No such technological breakthrough has been identified in the interagency report or other studies.

In the case of a wartime emergency, the U.S. Government may have to supply its allies with helium if their needs are significant. The peacetime requirements of a number of countries are now being supplied by private U.S. industry. It seems unlikely that foreign demand during wartime would significantly exceed the rapidly growing export capacity of U.S. industry.

Current annual demand for helium is approximately 0.9 billion cubic feet (Bcf). Estimated total cumulative demand to the year 2000 is approximately 30 Bcf. The 37.7 Bcf of Federal helium in storage would seem to be more than sufficient if it is decided that the stored helium should be designated as a national stockpile. In addition, according to the Interagency Helium Report, known non-depleting helium

resources on Federal lands are approximately 60 Bcf, of which nearly 45 Bcf are contained on the Tip Top Field in Wyoming. As contrasted with some other materials held in national stockpiles for strategic purposes, the United States is not dependent on foreign supplies for helium. On the contrary, most of the known helium resources in the world are located in the United States.

If the helium in Cliffside were designated as a national stockpile but the stockpile quantity set at a lower level than the 37.7 Bcf now in storage - between 20 and 30 Bcf - the business-as-usual base case would apply since cumulative Federal demand to the year 2000 has been projected at 12 Bcf. Thus, in combination with the 60 Bcf of Federally owned non-depleting helium resources, more than 80 Bcf of Federal helium will remain to meet long-term needs in the 21st century.

If the 37.7 Bcf of helium in Cliffside were designated a national stockpile, it would be necessary to define and describe the emergencies the stockpile would be used for. Or, by elimination, what it would not be used for. To provide incentives for private industry to invest in new helium extraction and purification facilities, a declaration that the stockpile would not be used for price stablization purposes may be necessary.

It is possible that if the government withdraws completely from the helium market, private industry might attempt to raise prices. Although the current market structure in the helium industry is oligopolistic with only a few firms in the market (see Appendix F for summary), for nearly 10 years, private producer prices have been substantially below the $35/Mcf price that the Bureau of Mines has charged Federal users. This implies that current price elasticities and the possibility of new entrants into the market provide a sufficient deterrent to the formation of a producers' cartel.

Study Topic 2

Permit Private Sector Purchases

Determine the effects of amending the Helium Act of 1960 to permit Federal agencies to purchase helium from the private sector. Government helium sales might be phased out over a period of time sufficient to allow private industry to increase production capacity to supply both Federal and private markets.

This section examines the effects of meeting future Federal helium demand through the private market. The effects are analyzed by comparing two alternative cases to a business-as-usual base case. The following 3 cases will be discussed:

Case 1 - Business-as-usual base case.

Case 2 - Phased transfer of the Federal helium market to private industry under a new National Helium Act, with continued operation of the Keyes facility.

Case 3 - Same as case 2, except the Keyes facility would be shut down at the end of 1980.

The analysis focuses on the financial and resource implications of the 3 cases. Major assumptions used in the calculations include:

- All calculations are to the year 2000.
- All calculations are in 1978 dollars.
- Bureau of Mines helium sales continue at $35/Mcf.
- Four years phase-out of Federal sales begins in 1980.
- Demand estimates are from the intermediate scenario of the Interagency Helium Study.
- In Case 1 and Case 2, the Keyes field is shut down at the end of 1986. In Case 3, it is assumed that the Keyes field is shut down at the end of 1980.
- In each case, Keyes production in excess of Federal sales is stored in the Cliffside reservoir.
- All calculations are independent of obligations related to the Helium Fund debt.

- Private market sales of pure helium are assumed at $20/Mcf. *

A complete listing of assumptions used in the calculations is included at the end of this section. The intermediate demand schedule and detailed financial and resource accounts are also included at the end of this section.

Financial Implications

A summary of the financial accounts is presented in Table 1. The "financing" column in Table 1 shows the receipts of the Bureau of Mines for helium purchased by other Federal agencies, and receipts from private firms for storage and purification services. The "obligations" column shows total estimated annual expenditures by the Bureau of Mines Helium Operations Division. If "obligations" are greater than "financing", the "additional funding" column indicates the appropriations necessary to cover these deficits. Any surplus of financing over obligations is credited to the Fund Balance in the table, but this surplus is normally returned to the Treasury.

Using the information in Table 1, the financial implications of implicating the phase-out case are as follows:

	(Millions)
• Helium fund surplus returned to the Treasury by the Bureau of Mines in base case ($306.6 - $1.5 minimum balance).....	$ 305.1
• Estimated appropriations to the Bureau of Mines helium activity in the phase-out case.....	51.5
• Sum of the foregone Treasury receipts and added appropriations required in the phase-out case.....	356.6
• Less the reduction in appropriations for Federal agencies for helium purchases in the private market, under the phase-out case. (($35 - $20) x 11.632 Bcf: Bureau of Mines price minus assumed private market price multiplied by estimated demand).....	174.5
• Increase in total Federal appropriations for the phase-out case.....	$ 182.1

* Private communications indicate that several recent helium contracts have been concluded at about $20/Mcf. Exact price data are proprietary and unavailable, but knowledgeable sources indicate that helium prices have not risen above the $20-$25/Mcf range in recent years.

Table 1. - Summary of Financial Accounts Bureau of Mines Projected Financing, Obligation, and Fund Balance to the Year 2000

(Millions of 78 Dollars)

Case:	Base Case 1/				Phase-Out Case 2/				Shut-Down Case 3/			
Fiscal Year	Financing	Obligations	Additional Funding 4/	End of Year Fund Balance 5/	Financing	Obligations	Additional Funding	End of Year Fund Balance 5/	Financing	Obligations	Additional Funding	End of Year Fund Balance 5/
1978	11.6	15.8	-	3.5	11.6	15.8	-	3.5	11.6	15.8	-	3.5
1979	11.7	11.2	-	4.0	11.7	10.7	-	4.5	11.7	11.0	-	4.2
1980	15.6	12.3	-	7.3	10.3	12.1	-	2.7	10.3	10.4	-	4.1
1981	16.5	13.6	-	10.2	10.2	12.4	1.0	1.5	10.2	8.0	-	6.3
1982	17.3	14.8	-	12.7	7.3	13.3	6.0	1.5	7.3	9.0	-	4.6
1983	18.1	11.4	-	19.4	3.6	8.6	5.0	1.5	3.6	5.1	-	3.1
1984	18.9	11.3	-	27.0	1.8	8.8	7.0	1.5	1.8	3.1	-	1.6
1985	19.8	11.4	-	35.4	1.8	8.1	6.3	1.5	1.8	3.1	1.2	1.5
1986	21.2	11.4	-	45.2	1.8	8.5	6.7	1.5	1.8	3.3	1.5	1.5
1987	22.6	10.0	-	57.8	2.0	4.1	2.1	1.5	2.0	3.3	1.3	1.5
1988	24.1	10.0	-	71.9	2.2	4.2	2.0	1.5	2.2	2.4	0.2	1.5
1989	25.5	10.2	-	87.2	2.5	4.4	1.9	1.5	2.5	2.6	0.1	1.5
1990	26.9	10.2	-	103.9	2.4	3.9	1.5	1.5	2.4	2.3	-	1.6
1991	27.6	10.2	-	121.3	0	1.2	1.2	1.5	0	1.2	1.1	1.5
1992	28.3	10.2	-	139.4	0	1.2	1.2	1.5	0	1.2	1.2	1.5
1993	29.0	10.2	-	158.2	0	1.2	1.2	1.5	0	1.2	1.2	1.5
1994	29.8	10.2	-	177.8	0	1.2	1.2	1.5	0	1.2	1.2	1.5
1995	30.5	10.1	-	198.2	0	1.2	1.2	1.5	0	1.2	1.2	1.5
1996	30.9	10.1	-	219.0	0	1.2	1.2	1.5	0	1.2	1.2	1.5
1997	31.4	10.1	-	240.3	0	1.2	1.2	1.5	0	1.2	1.2	1.5
1998	31.8	10.1	-	262.0	0	1.2	1.2	1.5	0	1.2	1.2	1.5
1999	32.2	10.1	-	284.1	0	1.2	1.2	1.5	0	1.2	1.2	1.5
2000	32.7	10.2	-	306.6	0	1.2	1.2	1.5	0	1.2	1.2	1.5
Total	554.0	255.1	-	306.6	69.2	126.9	51.5	1.5	69.2	91.6	16.2	1.5

1/ Bureau of Mines contunues present helium operations under existing helium legislation.

2/ Bureau of Mines gradually transfers its Federal market to private industry with Keyes plant operations.

3/ Bureau of Mines gradually transfers its Federal helium market to private industry with Keyes plant shut down.

4/ "Additional Funding" shows the appropriations necessary to cover the difference between "Financing" and "Obligation", except when the helium fund has a large enough balance to make up the deficit.

5/ Opening Balance $7.7 million. A minimum balance of $1.5 million is maintained.

Implementing the shut down alternative would reduce required total appropriations by $35.3 million over the phase out case ($51.5 - $16.2 the difference between additional funding columns, cases 2 and 3). Thus, the increase in total Federal Government appropriations between the base case and the shut down case would be $146.8 million.

These totals do not consider changes in income tax collections. Assuming that the additional private market sales of 11.6 Bcf of helium involve profits of about $4/Mcf, increased tax collections could total about $23 million. This amount should be substracted from the total increase in appropriations to derive the total cost to the Federal Government of the phase out and shut down alternatives.

The additional dollar costs determined in the above calculations should be compared to the benefits of maintaining our stockpile of helium at approximately the current level. Although the costs are given in terms of increased appropriations by the Congress, real economic costs are incurred by such additional expenditures. Whether the additional appropriations are obtained through taxes, increased Federal debt, or simply by printing money, the real costs are foregone consumption, investments, and savings.

Benefit Evaluation in Terms of Helium Resources

Based on estimates of natural gas production used in the Interagency Helium Study, the amount of helium contained in depleting and nondepleting natural gas fields in the year 2000 will be about 460 Bcf. This estimate does not include helium in the Cliffside storage facility.

Since helium contained in fuel natural gas is a coproduct, and is produced independently of the demand for helium, the estimated 460 Bcf of remaining helium resources is unaffected by the choice of scenario in this analysis. Shown in Table 2, the change in remaining resources from the base case to either alternative case is reflected in the inventory change in Cliffside.

Table 2
Federal Helium in the Cliffside Storage Reservoir

	1978	2000	Inventory Change	Difference from Base Case
Base Case	37.7 Bcf	27.0 Bcf	-10.7 Bcf	--
Phase Out	"	38.7 Bcf	+ 1.0 Bcf	+11.7 Bcf
Shut Down	"	37.5 Bcf	- 0.2 Bcf	+10.5 Bcf

NOTE: Material balance tables at the end of this section show Keyes field production and withdrawals from storage for the three cases.

A comparison of the base case to the phase out case shows that the expenditure of an additional $159.1 million under the phase-out option ($182.1 million less $23 million in estimated income taxes) would conserve an additional 11.7 Bcf of helium in the Cliffside stockpile by the year 2000. The benefit of the phase out case is the availability of additional crude helium at an opportunity cost of $13.60 Mcf. The cost/benefit analysis for both alternatives is presented in Table 3.

Table 3
Cost/Benefit Analysis for Alternatives

	Cliffside Storage in Year 2000 (Bcf)	Difference from Base Case (Bcf)	Cost Increment from Base Case (Millions of 78$)	Additional Cost Per Mcf Helium Saved
Base Case	27.0	---	---	---
Phase Out	38.7	+11.7	$159.1	$13.60/Mcf
Shut Down	37.5	+10.5	$123.8	$11.70/Mcf

If the phase out case is compared with the shut down case, the government would save $35.3 million, but would lose 1.2 Bcf of helium. That is, by going to the shut down alternative the government would forego 1.2 Bcf of crude helium, at an average cost of $29.42/Mcf.

To get a perspective on alternatives not considered here, an amended base case can be hypothesized in which all pending litigation is settled. The government would then be free to purchase crude helium in the private market rather than withdraw helium from Cliffside as in the base case. Assuming that helium can be purchased at the former contract price of about $12/Mcf for crude helium, and in sufficient quantities to leave Cliffside storage at the 38.7 Bcf level of the phase out case, the increased cost to the government under this amended base case would be about $140 million, as compared to the $159.1 million cost increment for the phase out case.

Complete List of Assumptions

Assumptions for the Base Case: Bureau of Mines (BOM) Continues Present Helium Operations Under P.L. 86-777.

a. BOM continues to supply Federal helium needs. Estimated demand corresponds to the intermediate level discussed in the Interagency Helium Study.

b. BOM continues extracting helium from natural gas produced from the Keyes field until low production and increased costs necessitate shut down in 1986. Production in excess of Federal helium needs will be stored.

c. BOM continues to sell helium to Federal agencies at $35 per Mcf.

d. BOM continues to purify helium at the Exell plant after the Keyes plant is shut down in FY 1986. New Federal capacity is added as necessary.

e. BOM continues conservation and storage, helium supply, demand and resources surveys, research and development, purification and redelivery of private-stored helium, etc.

Assumptions for the Phase Out Scenario: BOM Gradually Transfers Its Federal Helium Market to Private Industry under a New National Helium Act, Keyes Plant Operating

a. A new National Helium Act will be passed in FY 1979.

b. BOM helium sales to Federal agencies phased out gradually from FY 1980 through FY 1983.

c. Keyes helium production in excess of Federal helium needs will be stored.

d. Private industry will not reopen any of the former crude helium purchase contract plants (National Helium Corporation). One plant (Phillips Petroleum Company's Dumas Plant) is already shut down because of loss of gas supply. The announced plans of Linde Division, Union Carbide Corporation, to build a helium purification addition to the Northern Helex Company's crude helium plant will start production as planned. Additional purification capacity will likely be added by Cities Service Cryogenics and Alamo-Gardner as the gas supply and the helium market dictate.

e. Private helium purification capacity will expand starting in FY 1986 by approximately 150 MMcfy in FY 1990 and by approximately 500 MMcfy in FY 2000, in addition to Linde Division's announced expansion of 300 MMcfy in 1978.

f. Excess BOM buildings, process and distribution equipment, and real estate will be disposed of following the 4-year phase out.

g. BOM continues conservation and storage, helium supply, demand, and resources surveys, research and development, purification and redelivery of private stored helium, etc.

Assumptions for the Shutdown Scenario: BOM Gradually Transfers Its Federal Helium Market to Private Industry Under a New National Helium Act, Keyes Plant Shutdown in FY 1980.

a. A new National Helium Act will be passed in FY 1979.

b. BOM helium sales to Federal agencies are phased out gradually from FY 1980 to FY 1983.

c. Approximately 1.2 Bcf of helium will not be extracted at Keyes because of the shutdown at the end of FY 1980.

d. Private industry will add purification equipment to supply the shortfall in the helium market occasioned by the shutdown of the Keyes plant at the beginning of FY 1981.

e. Private helium purification capacity will have to expand starting in FY 1986 by approximately 150 MMcfy in FY 1990 and by approximately 500 MMcfy in FY 2000, in addition to Linde Digision's announced expansion of 300 MMcfy in 1978.

f. Excess plant and equipment from the Keyes plant will be disposed of following the shutdown.

g. BOM continues conservation and storage, helium supply, demand, and resources surveys, research and development, purification and redelivery of private stored helium, etc.

Table 4

Employment, Division of Helium, Bureau of Mines

Fiscal Year	Full-Time Permanent Employment		
	Base Case	Phase Out	Shut Down
1978	238	238	238
1979	238	238	238
1980	239	238	238
1981	241	233	138 1/
1982	242	217	138
1983	242	188	99
1984	242	188	99
1985	242	188	99
1986	242 2/	188	99
1987	202 3/	99 3/	99
1988	202	99	99
1989	202 4/	99	99
1990	202	99	99
1991	212 5/	30 6/	30 6/
1992	212	30	30
1993	212	30	30
1994	212	30	30
1995	212	30	30
1996	212	30	30
1997	212	30	30
1998	212	30	30
1999	212	30	30
2000	212	30	30

1/ Keyes plant shutdown. 360 MMcfy PSA unit added at Exell.

2/ First 360 MMcfy PSA unit added at Exell.
3/ Keyes plant shutdown.
4/ Second PSA unit added at Exell.
5/ Ten positions added to handle increasing Federal helium demand.
6/ Private stored helium inventory exhausted. Redelivery operations shutdown.

Table 5

Total Market for U.S. Helium by User

	FY 1978 Volume (MMcfy)	Percent of Domestic Sales
Federally Funded:		
Agencies	262	35
Contracts and Grants *	123	17
Subtotal	385	52
Private:	355	48
Total Domestic Sales	740	100
Exports:	200	
Total Sale of U.S. Helium	940 MMcf	

* Requirements for helium under government contracts or grants need not be purchased from the Federal Government. In 1968, a court order struck down Federal regulations requiring Federal agency contractors to purchase helium requirements directly from the Bureau. The judge ruled that it was the intent of the Helium Act Amendments of 1960 that Federally funded work use Federally produced helium. He recommended the appropriate means to achieve this end was for the agencies to require it in the agencies' contracts with their contractors. The above 123 MMcf is not covered by such stipulations.

Table 6

Estimated Total Demand for U.S. Helium 1/
(MMcfy at 14.7 PSIA and 70° F)

Year	Federal 2/	Private	Total
1978	262	678	940
1979	259	716	975
1980	352	658	1010
1981	372	672	1044
1982	392	686	1078
1983	412	700	1112
1984	432	714	1146
1985	452	728	1180
1986	486	728	1214
1987	520	727	1248
1988	555	727	1282
1989	589	728	1316
1990	623	727	1350
1991	640	744	1384
1992	658	760	1418
1993	675	777	1452
1944	693	793	1486
1945	710	810	1520
1996	720	834	1554
1997	731	857	1588
1998	741	881	1622
1999	752	904	1656
2000	762	928	1690

1/ Interagency Helium Study, Feb.1978, pp. 86 and 88.
2/ Federal helium demand is determined by program needs and is assumed to be price inelastic

NOTE: MMcfy is "million cubic feet per year."

Table 7

Base Case - Financial Accounts, Bureau of Mines Continues Present Helium Operations Under P.L. 86-777
(Millions of 78 Dollars)

Fiscal Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000
Financing 1/															
1. Purification and delivery of pure helium to Federal agencies 2/.....	10.6	10.7	14.6	15.5	16.3	17.1	17.9	18.8	20.2	21.6	23.1	24.5	25.9	29.5	31.7
2. Storage, purification, and delivery of private helium	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Additional funding.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total receipts.....	11.6	11.7	15.6	16.5	17.3	18.1	18.9	19.8	21.2	22.6	24.1	25.5	26.9	30.5	32.7
Fund balance beginning	7.7	3.5	4.0	7.3	10.2	12.7	19.4	27.0	35.4	45.2	57.8	71.9	87.2	177.8	284.1
Fund balance ending	3.5	4.0	7.3	10.2	12.7	19.4	27.0	35.4	45.2	57.8	71.9	87.2	103.9	198.2	306.6

1/ Income. Receipts and reimbursements for goods and services.
2/ Includes estimate of transportation charges.

Table 8

Base Case - Financial Accounts, Bureau of Mines Continues Present Helium Operations Under P.L. 86-777
(Millions of 78 Dollars)

Fiscal Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000
Program Obligations: 1/															
1. Production and storage of crude helium	1.7	1.5	1.5	0	0	0	0	0	0	0	0	0	0	0	0
2. Purification and delivery of pure helium to Federal agencies															
Keyes plant	3.4	3.3	3.3	3.2	3.3	3.3	3.4	3.3	3.4	0	0	0	0	0	0
Exell plant	5.4	2.0	2.6	5.0	5.5	3.4	3.3	3.3	3.3	5.6	5.6	5.7	5.8	5.9	6.0
Amarillo plant	1.0	0.6	0.6	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Subtotal	9.8	5.9	6.5	8.9	9.6	7.4	7.4	7.3	7.4	6.3	6.3	6.4	6.5	6.6	6.7
3. Storage, purification, and delivery of private helium															
Keyes plant	1.9	1.7	1.8	2.0	2.1	1.5	1.5	1.6	1.5	0	0	0	0	0	0
Exell plant	1.7	1.5	1.6	1.7	1.9	1.3	1.3	1.4	1.4	2.7	2.7	2.7	2.7	2.6	2.6
Subtotal	3.6	3.2	3.4	3.7	4.0	2.8	2.8	3.0	2.9	2.7	2.7	2.7	2.7	2.6	2.6
4. Helium resources investigations and evaluations, supply/demand analyses, and research and development	0.7	0.6	0.9	1.0	1.2	1.2	1.1	1.1	1.1	1.0	1.0	1.1	1.0	0.9	0.9
Total obligations	15.8	11.2	12.3	13.6	14.8	11.4	11.3	11.4	11.4	10.0	10.0	10.2	10.2	10.1	10.2

1/ All obligations assessed against cost centers do not coincide with cost representation in charge structure.

Table 9

Phase-Out Case - Financial Accounts, Bureau of Mines Gradually Transfers Its Federal Helium Market to Private Industry, Keyes Plant Operating

(Millions of 78 Dollars)

Fiscal Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000
Financing 1/															
1. Purification and delivery of pure helium to Federal agencies...	10.6	10.7	9.3	9.1	5.9	2.0	0	0	0	0	0	0	0	0	0
2. Storage, purification, and delivery of private helium.....	1.0	1.0	1.0	1.1	1.4	1.6	1.8	1.8	1.8	2.0	2.2	2.5	2.4	0	0
Additional funding.....	0	0	0	1.0	6.0	5.0	7.0	6.3	6.7	2.1	2.0	1.9	1.5	1.2	1.2
Total receipts.....	11.6	11.7	10.3	11.2	13.3	8.6	8.8	8.1	8.5	4.1	4.2	4.4	3.9	1.2	1.2
Fund balance beginning.....	7.7	3.5	4.5	2.7	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Fund balance ending.....	3.5	4.5	2.7	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

1/ Income. Receipts and reimbursements for goods and services.

Table 10

Phase-Out Case - Financial Accounts, Bureau of Mines Gradually Transfers Its Federal Helium Market to Private Industry, Keyes Plant Operating

(Millions of 78 Dollars)

Fiscal Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000
Program Obligations 1/															
1. Production and storage of crude helium	1.7	2.1	1.7	2.6	4.2	3.4	3.5	3.2	3.3	1.8	1.8	1.8	1.6	0	0
2. Purification and delivery of pure helium to Federal agencies															
Keyes plant	3.4	2.7	2.2	2.1	0.6	0.1	0	0	0	0	0	0	0	0	0
Exell plant	5.4	1.1	2.1	0.7	0.5	0.1	0	0	0	0	0	0	0	0	0
Amarillo plant	1.0	0.9	0.7	0.6	0.2	0.1	0	0	0	0	0	0	0	0	0
Subtotal	9.8	4.7	5.0	3.4	1.3	0.3	0	0	0	0	0	0	0	0	0
3. Storage, purification, and delivery of private helium															
Keyes plant	1.9	2.0	3.0	3.6	4.3	1.9	2.4	2.3	2.4	0	0	0	0	0	0
Exell plant	1.7	1.2	1.4	1.7	2.2	1.9	1.8	1.6	1.7	1.1	1.1	1.2	1.1	0	0
Subtotal	3.6	3.2	4.4	5.3	6.5	3.8	4.2	3.9	4.1	1.1	1.1	1.2	1.1	0	0
4. Helium resources investigations and evaluations, supply/demand analyses, and research and development	0.7	0.7	1.0	1.1	1.3	1.1	1.1	1.0	1.1	1.2	1.3	1.4	1.2	1.2	1.2
Total obligations	15.8	10.7	12.1	12.4	13.3	8.6	8.8	8.1	8.5	4.1	4.2	4.4	3.9	1.2	1.2

1/ Obligation assessed against cost centers do not coincide with cost representation in charge structure.

Table II

Shut-Down Case - Financial Accounts, Bureau of Mines Gradually Transfers Its Federal Helium Market to Private Industry, Keyes Plant Shutdown

(Millions of 78 Dollars)

Fiscal Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000
Financing 1/															
1. Purification and delivery of pure helium to Federal agencies.....	10.6	10.7	9.3	9.1	5.9	2.0	0	0	0	0	0	0	0	0	0
2. Storage, purification, and delivery of private helium.....	1.0	1.0	1.0	1.1	1.4	1.6	1.8	1.8	1.8	2.0	2.2	2.5	2.4	0	0
Additional funding.....	0	0	0	0	0	0	0	1.2	1.5	1.3	0.2	0.1	0	1.2	1.2
Total receipts.....	11.6	11.7	10.3	10.2	7.3	3.6	1.8	1.8	3.2	3.3	2.4	2.6	2.4	1.2	1.2
Fund balance beginning.....	1.7	3.5	4.2	4.1	6.3	4.6	3.1	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Fund balance ending.....	3.5	4.2	4.1	6.3	4.6	3.1	1.6	1.5	1.5	1.5	1.5	1.5	1.6	1.5	1.5

1/ Income. Receipts and reimbursements for goods and services.

Table 12

Shut-Down Case - Financial Accounts, Bureau of Mines Gradually Transfers Its Federal Helium Market to Private Industry, Keyes Plant Shutdown

(Millions of 78 Dollars)

Fiscal Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000
Program Obligations 1/															
1. Production and storage of crude helium	1.7	1.5	1.5	0	0	0	0	0	0	0	0	0	0	0	0
2. Purification and delivery of pure helium to Federal agencies															
Keyes plant	3.4	2.7	2.3	0	0	0	0	0	0	0	0	0	0	0	0
Exell plant	5.4	2.0	2.3	3.2	3.4	1.9	0	0	0	0	0	0	0	0	0
Amarillo plant	1.0	0.9	0.7	0.6	0.2	0.1	0	0	0	0	0	0	0	0	0
Subtotal	9.8	5.6	5.3	3.8	3.6	2.0	0	0	0	0	0	0	0	0	0
3. Storage, purification, and delivery of private helium															
Keyes plant	1.9	2.0	1.2	0	0	0	0	0	0	0	0	0	0	0	0
Exell plant	1.7	1.2	1.4	3.1	4.1	2.0	2.2	2.1	2.2	2.1	1.1	1.2	1.1	0	0
Subtotal	3.6	3.2	2.6	3.1	4.1	2.0	2.2	2.1	2.2	2.1	1.1	1.2	1.1	0	0
4. Helium resources investigations and evaluations, supply/demand analyses, and research and development	0.7	0.7	1.0	1.1	1.3	1.1	1.1	1.0	1.1	1.2	1.3	1.4	1.2	1.2	1.2
Total obligations	15.8	11.0	10.4	8.0	9.0	5.1	3.3	3.1	3.3	3.3	2.4	2.6	2.3	1.2	1.2

1/ All obligations assessed against cost centers do not coincide with cost representation in charge structure.

Table 13

Base Case - Helium Material Balance, Bureau of Mines Continues Present Helium Operations Under P.L. 86-777

(MMcfy at 14.7 PSIA and 70° F)

Fiscal Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000
Keyes Plant 1/															
From Keyes field	331	329	294	256	223	195	171	150	123	0	0	0	0	0	0
Federal helium sales	262	259	265	265	265	265	265	265	265	0	0	0	0	0	0
To (from) Government storage 2/	69	70	29	(9)	(42)	(70)	(94)	(115)	142) 2/	0	0	0	0	0	0
Private pure helium redelivered	185	185	185	185	185	185	185	185	185	0	0	0	0	0	0
Helium from storage	116	115	156	194	227	255	279	300	327	0	0	0	0	0	0
Exell Plant															
Federal helium sales	0	0	87	107	127	147	167	187	221	520	555	589	623	710	76
(From) Government storage 2/	0	0	(87)	(107)	(107)	(147)	(167)	(187)	(221)	(520)	(555)	(589)	(623) 3/	(710)	(76
Private pure helium redelivered	0	0	0	0	0	0	0	0	0	185	185	185	185	185	18
Helium from storage 2/	0	0	87	107	127	147	167	187	221	705	740	774	808 3/	895	94
Total															
Federal helium sales	262	259	352	372	392	412	432	452	486	520	555	589	623	710	76
To (from) Government storage	69	70	(58)	(116)	(169)	(217)	(261)	(302)	(363)	(520)	(555)	(589)	(623)	(710)	(76
Private pure helium redelivered	185	185	185	185	185	185	185	185	185	185	185	185	185	185	18
Helium from storage 2/	116	115	243	301	354	402	446	487	548	705	740	774	808 3/	895	94

1/ 450 MMcfy capacity.

2/ Helium is from prior production at Keyes.

3/ Stored Keyes helium depleted.

Table 14

Phase-Out Case - Helium Material Balance, Bureau of Mines Gradually Transfers Its Federal Helium Market to Private Industry, Keyes Plant Operating

(MMcfy at 14.7 PSIA and 70°F)

Fiscal Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000
Keyes Plant 1/															
From Keyes field.....	331	329	294	256	223	195	171	150	123	0	0	0	0	0	0
Federal helium sales.....	262	259	225	220	142	48	0	0	0	0	0	0	0	0	0
To (from) Government storage.....	69	70	69	36	81	147	171	150	123	0	0	0	0	0	0
Private pure helium re-delivered	185	185	202	251	304	356	390	400	400	0	0	0	0	0	0
Helium from storage.....	116	115	133	215	223	209	219	250	277	0	0	0	0	0	0
Exell Plant															
Federal helium sales.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(From) Government storage.....	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Private pure helium redelivered 2/.....	0	0	0	0	0	0	0	0	0	434	494	553	524	0	0
Helium from storage.....	0	0	0	0	0	0	0	0	0	434	494	553	524	0	0
Total															
Federal helium sales.....	262	259	225	220	142	48	0	0	0	0	0	0	0	0	0
To (from) Government storage.....	69	70	69	36	81	147	171	150	123	0	0	0	0	0	0
Private pure helium redelivered 2/	185	185	202	251	304	356	390	400	400	434	494	553	524	0	0
Helium from storage.....	116	115	133	215	223	209	219	250	277	434	494	553	524	0	0

1/ 450 MMcfy capacity.
2/ Volumes greater than 400 MMcfy would be in crude form.

Table 15

Shut-Down Case - Helium Material Balance, Bureau of Mines Gradually Transfers Its Federal Helium Market to Private Industry, Keyes Plant Shutdown

(MMcfy at 14.7 PSIA and 70°F)

Fiscal Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1995	2000
Keyes Plant 1/															
From Keyes field	331	329	294	0	0	0	0	0	0	0	0	0	0	0	0
Federal helium sales	262	259	225	0	0	0	0	0	0	0	0	0	0	0	0
To (from) Government storage	69	70	69	0	0	0	0	0	0	0	0	0	0	0	0
Private pure helium redelivered	185	185	202	0	0	0	0	0	0	0	0	0	0	0	0
Helium from storage	116	115	133	0	0	0	0	0	0	0	0	0	0	0	0
Exell Plant															
Federal helium sales	0	0	0	220	142	48	0	0	0	0	0	0	0	0	0
(From) Government storage	0	0	0	(220)	(142)	(48)	0	0	0	0	0	0	0	0	0
Private pure helium redelivered 2/	0	0	0	251	304	356	390	400	400	434	494	553	524	0	0
Helium from storage	0	0	0	471	446	404	390	400	400	434	494	553	524	0	0
Total															
Federal helium sales	262	259	225	220	142	48	0	0	0	0	0	0	0	0	0
To (from) Government storage	69	70	69	(220)	(142)	(48)	0	0	0	0	0	0	0	0	0
Private pure helium redelivered 2/	185	185	202	251	304	356	390	400	400	434	494	553	524	0	0
Helium from storage	116	115	133	471	446	404	390	400	400	434	494	553	524	0	0

1/ 450 MMcfy capacity.
2/ Volumes greater than 400 MMcfy would be in crude form.

Study Topic 3

Cancelling the Helium Debt

Determine the feasibility and costs of (a) cancelling the outstanding helium debt, and (b) financing or supplementing the finances of the program by annual appropriations if Federal helium sales were to be discontinued.

According to the Interagency Report, the financing of the Federal Helium Program is regulated by sections 6c, d, f, and 12 of the Helium Act. A "helium production fund" without fiscal year limitation was established to receive proceeds from the sale of Bureau helium and borrowings from the Treasury, and to disperse these funds as required for program operations, including purchases of crude helium and repayment of borrowings.

The statement of the financial condition of the Federal Helium Program as of October 1, 1977, is shown in Table 16. The principal asset is the helium purchased from 1962 to 1973. Approximately $360 million worth of helium was purchased during that period. Approximately $110 million of that amount came from operating income of the Bureau helium program. The balance of approximately $250 million was borrowed from the Treasury. These borrowings, along with the net worth of the Helium Program Fund debt of 1960 of approximately $40 million, plus the compound interest, constitute the major financial liability of the program. Repayments of $1 million during each of the last 2 years and FY 1978 have been made from operating income. Compound interest is currently accruing at a rate of about $30 million per year, while total program receipts are about $12 million per year. Amounts are presented in Table 17.

The Helium Act requires the Secretary of Interior to repay the principal plus compound interest by 1985. The Secretary may obtain a 10-year extension on this requirement if necessary.

With the growth of private helium production during the 1960's and the sharp reduction in demand for Federal uses, actual sales of the Bureau of Mines have differed significantly from the expectations on which the debt repayment schedule was based. Under the business-as-usual base case (and even more so under the alternatives considered in this report), the debt will continue to grow.

Based on current demand projections, it is unlikely that the helium debt could ever by paid off under any scenario and the accounting burden it creates should be eliminated by an Act of Congress. Any surplus arising from current operation of the helium activity would be returned to the Treasury in any event.

Table 16

Bureau of Mines Division of Helium, Financial Condition, as of September 30, 1977 1/

Assets		Liabilities and Net Worth	
Current		Current	
Total Assets.....	$ 11,504,995	Total Liabilities.....	$ 30,858,727
Fixed Assets:			
Helium in underground storage 2/...	$590,196,710	Long-Term Indebtedness to U.S. Treasury.....	$466,451,156
Plants, property, and equipment (net).....	$ 24,590,449	Total Liabilities...	$497,309,883
Total Fixed Assets.....	$614,787,159	Total Net Worth.....	$128,982,271
Total Assets	$626,292,154	Total Liabilities... and Net Worth.....	$626,292,154

1/ Includes value of helium delivered under court-ordered injunction.
2/ The value of the helium was determined by including purchase cost, interest charges, transportation cost to the storage facility, production costs of government helium, and pressure maintenance plant deprecation.

Table 17

Helium Fund Debt and Estimates of Debt Growth Under Present Operating Conditions, Million Dollars

Fiscal Year	Principal 1/	Cumulative Interest 1/	Total Debt 2/
1961	41	-	41
1962	41	3	43
1963	41	4	45
1964	37	5	42
1965	57	7	64
1966	76	10	86
1967	99	14	113
1968	129	19	148
1969	145	26	171
1970	175	36	211
1971	241	48	289
1972	285	64	349
1973	286	83	369
1974	286	104	390
1975	286	126	412
1976	285	150	435
1977	284	182	466
1978 3/	283	210	493
1979 3/	283	241	524
1980 3/	283	273	556
1985 3/	283	473	756
1990 3/	283	756	1,039
1995 3/	283	1,159	1,442

1/ Might have rounding error.
2/ Principal plus compound interest.
3/ Estimated.

Discussions with the Treasury Department have identified a model for the cancellation of this type of debt. A precedent is contained in the Defense Production Act Amendments of 1974 (P.L. 93-426, dated September 30, 1974). This Act, which amends and extends the Defense Production Act of 1950, cancelled the outstanding obligations to the Treasury accumulated under the borrowing authority, and substituted conventional appropriations methods for supporting future programs. The original borrowing authority was used to expand production capacity by various means, including purchases of materials for stockpiles. Anticipated future sales of stockpiled materials were to sustain the liquidity of the fund and repay the debt. For reasons beyond the control of the parties involved, these future sales did not materialize, and the debts continued to grow due to interest obligations. In the absence of legislation, the Defense Production Act fund would have gone backrupt.

Under the Defense Production Act Amendments of 1974, appropriations are required to cover the cost of new purchases as well as interest payments on the value of the current inventory. Such a procedure would reflect the full costs of maintaining the inventory, both maintenance and financial costs, and would improve Congressional surveillance and control of the program. It should be noted that the appropriations associated with the cases discussed in the preceding section do not include interest payments on the value of the helium inventory.

Study Topic 4

Encourage Private Helium Storage

> Evaluate the desirability of policies which might be used to encourage extraction and storage of helium from fuel (high-Btu) gas, including the effectiveness of low storage fees, ready return, or other incentives for encouraging the storage of privately owned helium at the Cliffside reservoir. This might include examining the feasibility and costs of encouraging the conservation of helium by the private sector through amendments to the Internal Revenue Code to (a) permit the cost of helium extraction and transportation for conservation and storage to be deducted as an expense for the year in which such expense is incurred, and (b) recapture such deductions at the time the helium is sold.

In the past, several mechanisms for encouraging private storage of crude helium have been considered. Low storage fees at the Cliffside reservoir have been in operation since 1975. These fees are based on the incremental cost ($0.04/Mcf/year) of maintaining additional storage in the reservoir. Lower fees than that would be below the break-even level, and violate current regulations which forbid operating at a loss. Since the 1975 fee schedule has been in effect, eleven contracts for helium storage have been signed. Net storage (total minus redeliveries) is currently about 300 MMcf/year.

If an increase in the rate of private storage is deemed desirable, a subsidy program could be designed that would encourage the storage of additional private helium in Cliffside. Discussions with the Treasury Department have identified a tax credit as a possible mechanism for such a subsidy. A tax credit is equivalent to offering a fixed price subsidy for each unit of helium delivered to a designated storage facility. But in lieu of appropriations to the Department of the Interior to pay for such a program, a credit against income taxes would be allowed to storing companies. The total amount of the tax credit must be deducted from the cost of goods sold when the storing companies determine taxable income. Tax credits have been used in other programs, such as the jobs program, and are considered by Treasury as an effective and manageable mechanism for providing tax incentives.

A tax credit for helium storage would avoid the controversy over costs of production that has arisen in the current helium litigation. No cost figures need be proved, and each company would base its decision to store helium on internal calculations. In addition, administration of the program is relatively straightforward, since it only depends on an accurate measure of the amount of stored helium.

The level of the tax credit would be set by Congress, and could be adjusted by Congress from time to time to suit changing policy goals.

Those companies using Cliffside to hold working inventories would not be given a credit on helium put into Cliffside when a like amount is redelivered either as crude or in purified form. The tax credit should be structured so that companies are given a tax credit only for net additions to their stored quantities each year after the effective date of the tax credit.

According to the Bureau of Mines estimates of depleting proved and probable natural gas, there will be a surplus of helium available for processing between now and the end of the century. During this period, the gas processing plants that have access to the helium-rich gas streams will have available about 50 Bcf of helium, of which 16 Bcf are estimated to be required to satisfy private market demand. The remaining 34 Bcf could be available for storage in the Cliffside facility.

Since these plants already exist, and the incremental costs of extracting much of the helium and delivering that helium to storage are relatively small, a relatively low tax credit could result in signficant additions to storage.

For a tax credit in the range of $2-$5/Mcf, the total tax credit for the estimated 4.4 Bcf available for storage in 1979 would be between $8.8 million and $22 million, and $68-$170 million for the entire 34 Bcf estimated to be available between now and the year 2000.

Determining the appropriate level of the tax credit will depend on balancing the credit level with the amount of stored helium desired. High credit levels could result in high storage levels, and could possibly encourage the construction of additional helium extraction capacity.

The effectiveness of a tax credit is difficult to assess. Currently, there is only one company venting helium to the atmosphere (at a rate of 600 MMcf/year). This firm's involvement in litigation over the cancellation of the helium contracts and the setting of a reasonable royalty rate for helium may override any incentives that might be created by a tax credit.

Study Topic 5

Assess the Keyes Plant Role

Appraise on a regular basis the role of the Keyes plant and other government helium properties in meeting the national needs for pure helium production. One issue might be utilization of the Keyes plant to supplement private production as needed if government helium sales were to be phased out.

Federal helium facilities are located in the northern portion of the Texas Panhandle, the Oklahoma Panhandle, and southwestern Kansas. These facilities consist of two helium plants located near Keyes, Oklahoma and Masterson, Texas; a transportation service, liquefaction, and repair service plant in Amarillo, Texas; general field management and program offices in downtown Amarillo; the Cliffside Gas Field 18 miles northwest of Amarillo; and a 425 mile pipeline system connecting the three government plants and the former contractor plants to the storage reservoir (Cliffside Field). This pipeline was used from 1962 until 1973 to transport and store helium purchased from former contractors and excess helium produced at Bureau plants. It is in use today for transporting helium from the government's helium plants at Keyes, Oklahoma, and Masterson, Texas, and to and from some of the companies that have contracts with the Bureau for storage of privately owned helium. The Keyes plant extracts and purifies helium. Table 18 shows the capacities of the Keyes and Exell plants. The Exell plant performs helium processing operations for conservation storage, and serves as a back-up purification facility for Keyes. Figures 1 through 6 show the locations and functions of all the Bureau of Mines helium facilities. Figure 7 shows the location of both Federal and private helium plants in the Hugoton-Panhandle area.

The Keyes plant is extracting helium from the natural gas produced from the Keyes field under a life-of-the-field contract. This field will be nearly depleted by 1986. The Keyes plant will be of little use then because of its location and design. However, the planned improvements and additions to Exell shown in Table 18 will bring that plant's capacity to 1,944 MMcfy of crude and 601 MMcfy of pure helium by the middle 1980's.

Estimated total future helium demand can be met by existing and planned private and Federal facilities at least through 1990. Private production capacity has kept pace with private helium demand over the past 10 years, and there is no reason to believe that this will not continue in the future. Currently, private pure helium capacity is 599 MMcfy as shown in Table 19. An additional 300 MMcfy of pure helium capacity is now under construction at the Northern Helex Plant in Bushton, Kansas.

This expansion incorporates a new non-cryogenic helium purification process called pressure swing adsorption (PSA) that can produce high-purity helium from crude helium at about one-fourth the cost of cryogenic purification. If the PSA process proves successful at this large scale, the proposed mid-1980's expansion of the Exell facility may incorporate the PSA technology.

Table 18

Bureau of Mines Capacity of Helium Extraction and Purification
(MMcfy at 14.7 PSIA and 70°F)

Plant	Annual Design Capacity Crude	Pure
Keyes Helium Plant - existing	511 1/	450
Exell Helium Plant - existing	1,944 2/	72
Additional equipment operational by 1979 3/		241
Proposed equipment operational by 1985 4/		360
	2,455	1,051 5/

1/ Design capacity. Crude extraction will drop as the Keyes field depletes.
2/ Unit II is operated to accommodate the helium storage program.
3/ New purifier being obtained by contract.
4/ Pressure-swing adsorption purification unit.
5/ Operation of the old Exell purifiers (72 MMcfy capacity) would be discontinued after the proposed pressure swing unit is operational.

Table 19

Summary of Private Helium Production Capacity and Employment
(All volumes in MMcfy at 14.7 PSIA & 70°F)

Plant	Plant Design Capacity		Natural Gas Reserves	Helium Reserves	Estimated Employment Related to Helium
	Crude	Pure			
Former Crude Helium Contractors					
Cities Service Helex	773		3,169,195	13,628	55
Northern Helex	798	75[2]	3,011,545	11,035	57[3]
Phillips Petroleum					
Dumas	656[1]				
Sherman	607		452,176	3,165	7
National Helium Corp.	1,210[1]				
Other Private Plants					
Alamo Chemical Corporation	168	168	79,609	442	25
Cities Service Cryogenics	203	203	944,840	4,460	12
Kansas Refined Helium	105	153	45,100	1,891	20
Western Helium Corp.	71[1]	71[1]			
Total (excludes nonoperating plants)	2,583	599	7,702,465	34,621	176

1/ Plants not operating and not expected to restart.
2/ Linde purification addition to Helex.
3/ Includes 50 employees at Northern Helex and 7 at the Linde purification facility.

Table 20

U.S. Private Industry High-Purity Helium Sales 1/, Calendar Year 1961-1977
(Million Cubic Feet at 14.7 PSIA and 70°F)

Plant	Date of Operation	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Kerr-McGee	11/61	2	30	35	46	58	63	74	65	54	61	57	54	43				
Kansas Refined Helium	4/66					-	75	138	156	121	117	137	138	149	NA	NA	NA	152
Greenwood	12/66					-	2/	87	102	103	96	86	110	106	NA	NA	NA	156
Linde Division 3/	9/67-10/68						-	1	30	-	-	-	-	-	-	-	-	-
Cities Service Cryogenics	10/68							-	19	111	140	120	136	162	NA	NA	NA	282
Teec Nos Pos 4/	5/68-9/69							-	2/	2	-	-	-	-	-	-	-	-
Navajo	10/68-9/69								2	13	2/	-	-	-	-	-	-	-
Western Helium	10/68-9/69 5/ 3/72								-	2/	2	-	12	7	NA	NA	NA	
Total Sales		2	30	35	46	58	138	300	374	404	416	400	450	467	530	561	574 6/	590 6/

NA - Not available

1/ Helium sales from 1961 through 1967 are generally based on the Bureau's knowledge of the helium market and contacts with helium producers and suppliers. From 1968-1973, the helium sales volumes were furnished by the private companies. No data on individual plant sales are available from 1974 to 1976. The 1977 data were obtained from the private companies.

2/ Sales less than 1 MMcf.

3/ Linde (at Amarillo, Texas) purified crude helium purchased from Cities Service.

4/ Most of the helium produced at this plant was purified at the Navajo plant.

5/ Plant closed but resumed intermittent operations in 1975.

6/ Does not include 49 MMcf of pure helium redelivered to private companies from Bureau production in 1976 or 202 MMcf redelivered to private companies from Bureau production in 1977.

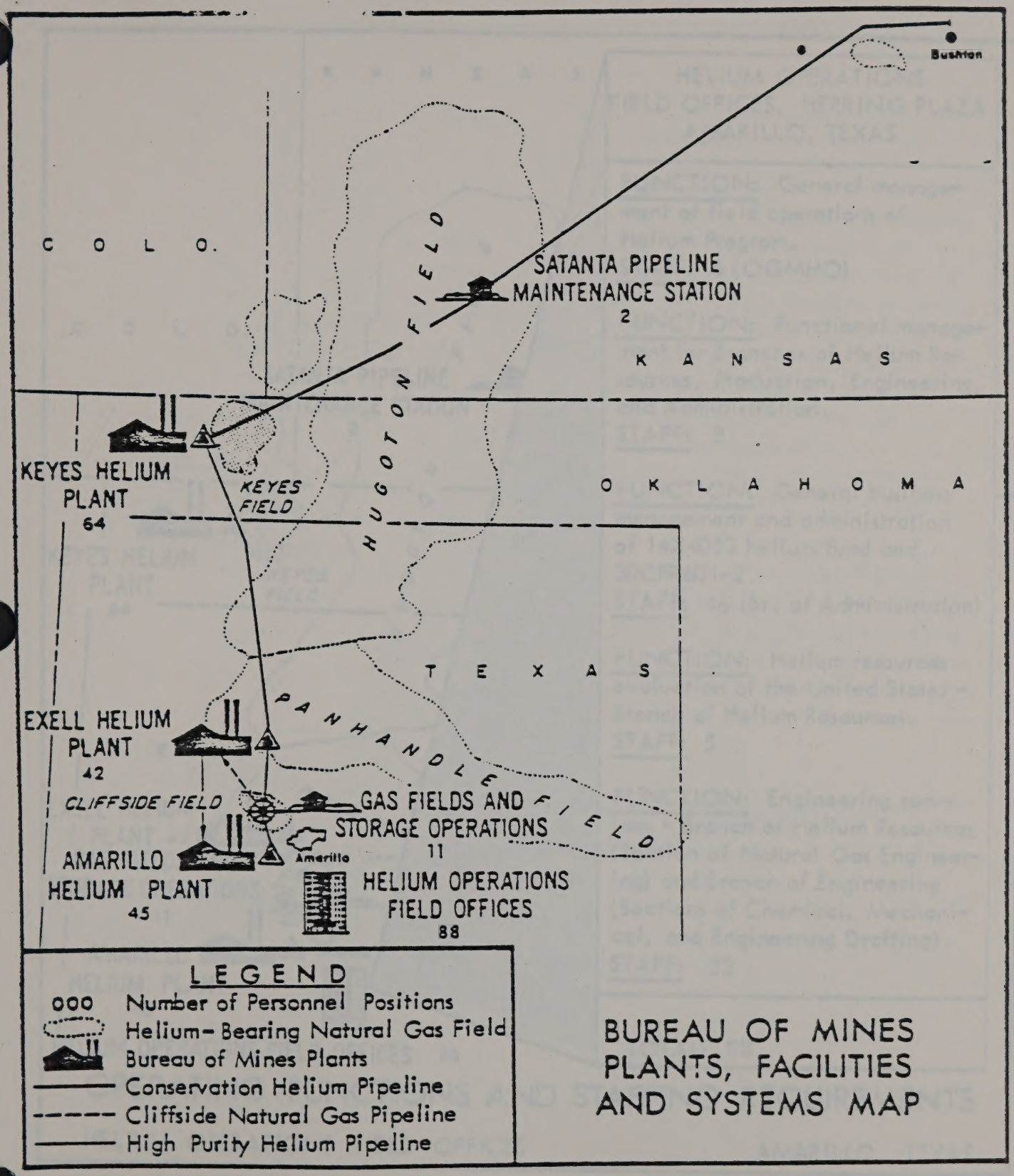
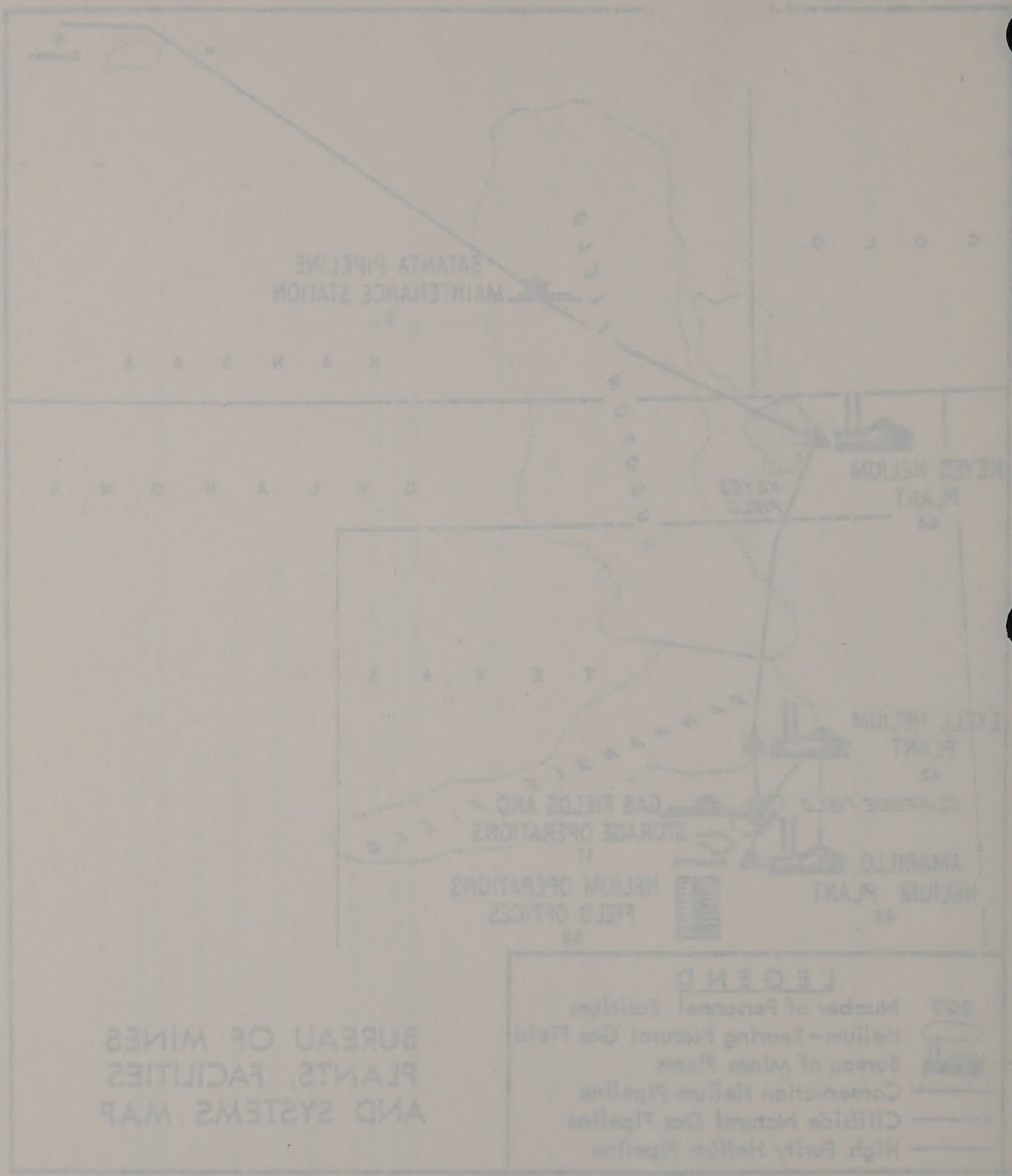


Figure 1 - Bureau of Mines Plants


BUREAU OF MINES
PLANTS, FACILITIES
AND SYSTEMS MAP

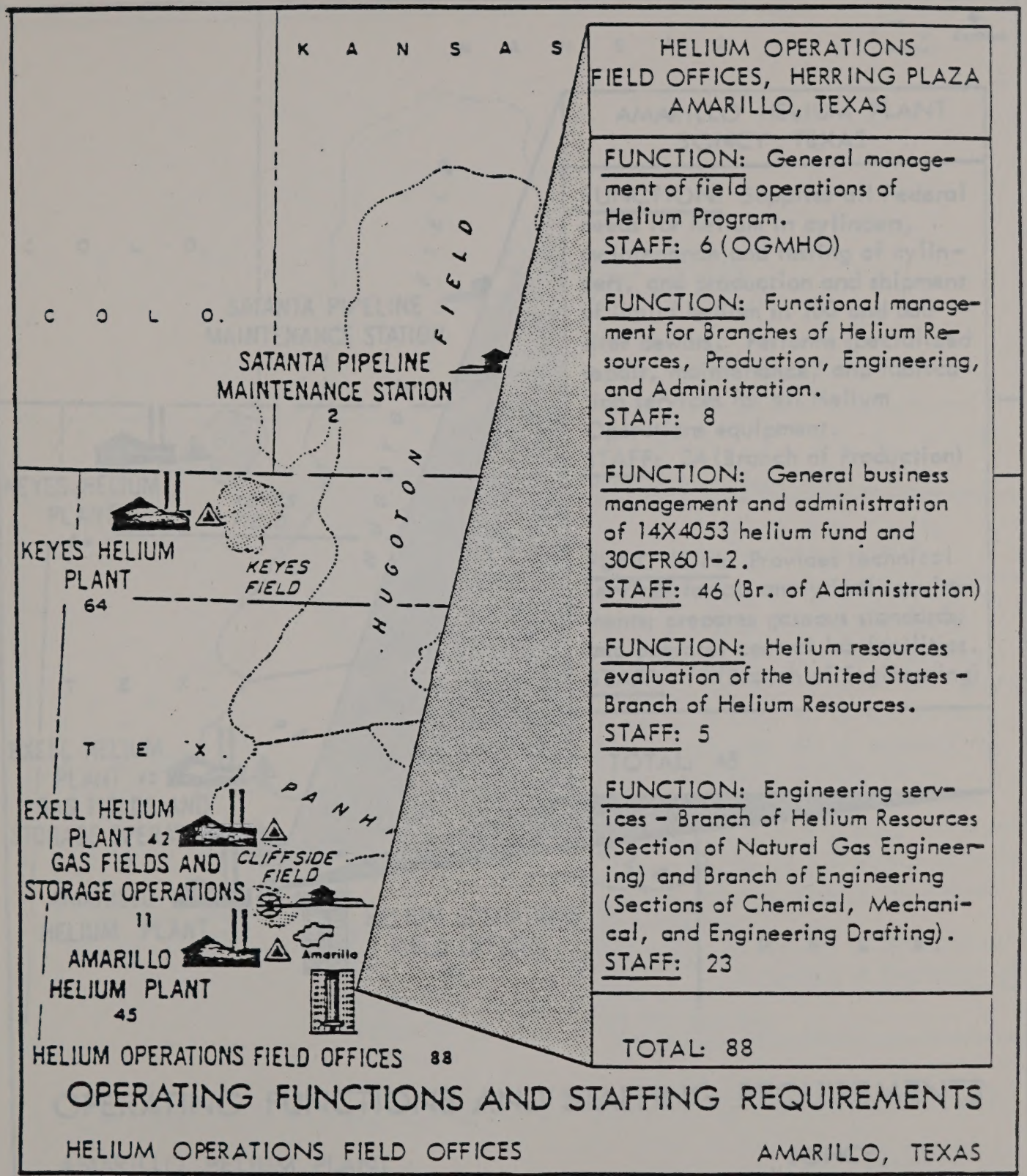
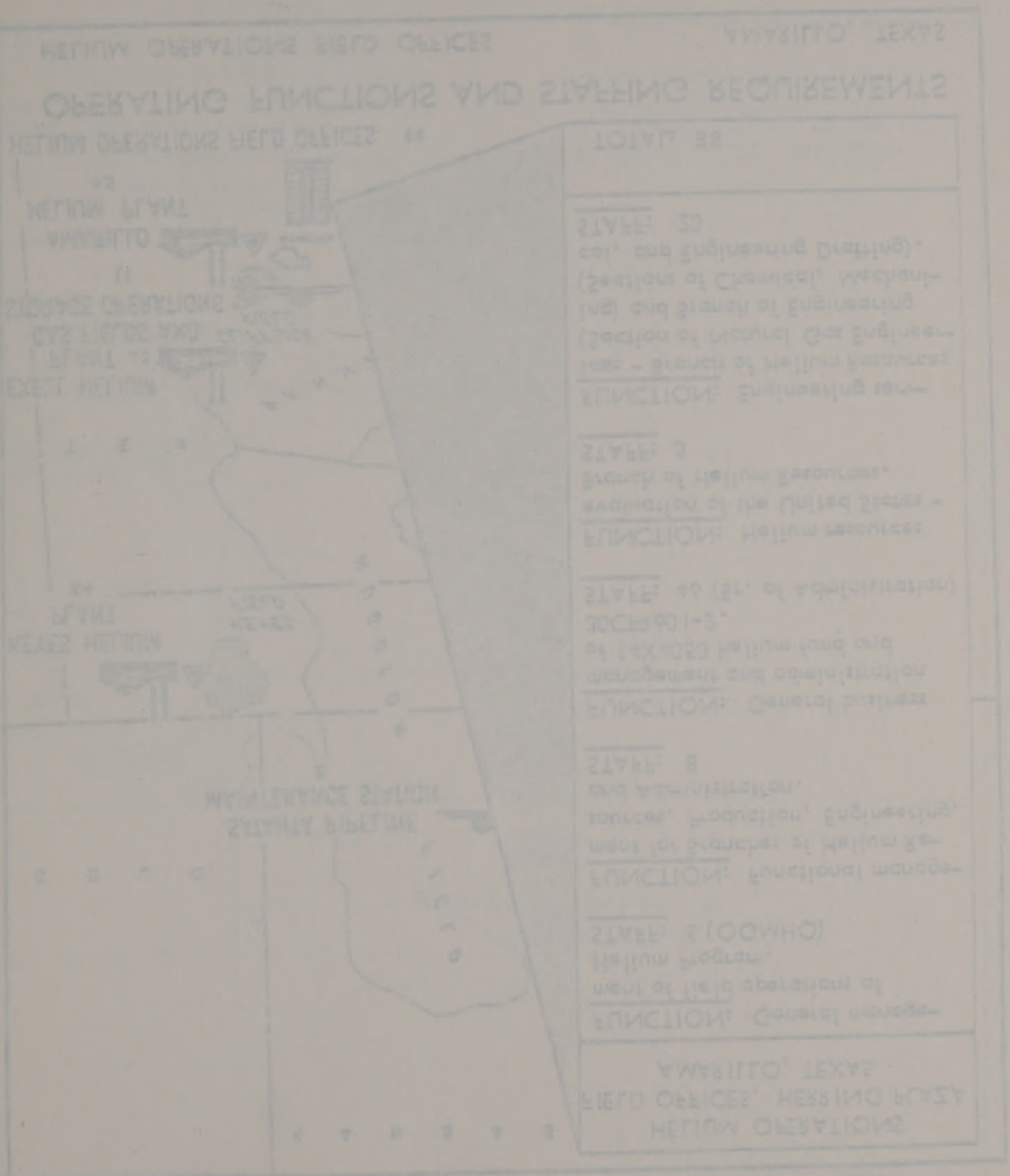

K A N S A S
C O L O.
T E X.
HUGOTON FIELD
PANHANDLE
SATANTA PIPELINE MAINTENANCE STATION 2
KEYES HELIUM PLANT 64
KEYES FIELD
EXELL HELIUM PLANT 42
GAS FIELDS AND STORAGE OPERATIONS 11
CLIFFSIDE FIELD
AMARILLO HELIUM PLANT 45
Amarillo
HELIUM OPERATIONS FIELD OFFICES 88
HELIUM OPERATIONS FIELD OFFICES, HERRING PLAZA AMARILLO, TEXAS
FUNCTION: General management of field operations of Helium Program.
STAFF: 6 (OGMHO)
FUNCTION: Functional management for Branches of Helium Resources, Production, Engineering, and Administration.
STAFF: 8
FUNCTION: General business management and administration of 14X4053 helium fund and 30CFR601-2.
STAFF: 46 (Br. of Administration)
FUNCTION: Helium resources evaluation of the United States - Branch of Helium Resources.
STAFF: 5
FUNCTION: Engineering services - Branch of Helium Resources (Section of Natural Gas Engineering) and Branch of Engineering (Sections of Chemical, Mechanical, and Engineering Drafting).
STAFF: 23
TOTAL: 88
OPERATING FUNCTIONS AND STAFFING REQUIREMENTS
HELIUM OPERATIONS FIELD OFFICES
AMARILLO, TEXAS

Figure 2 - Amarillo Field Office



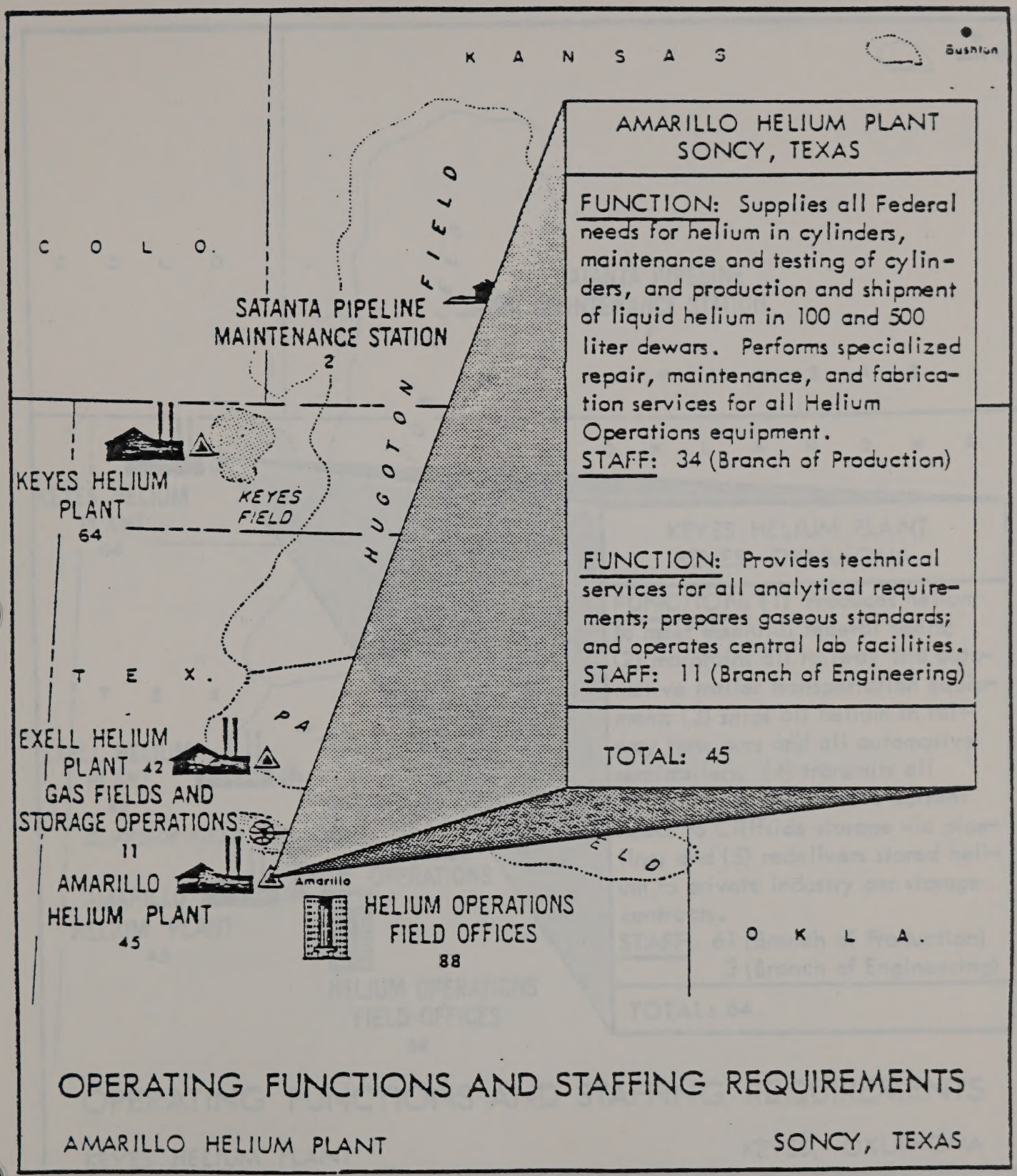
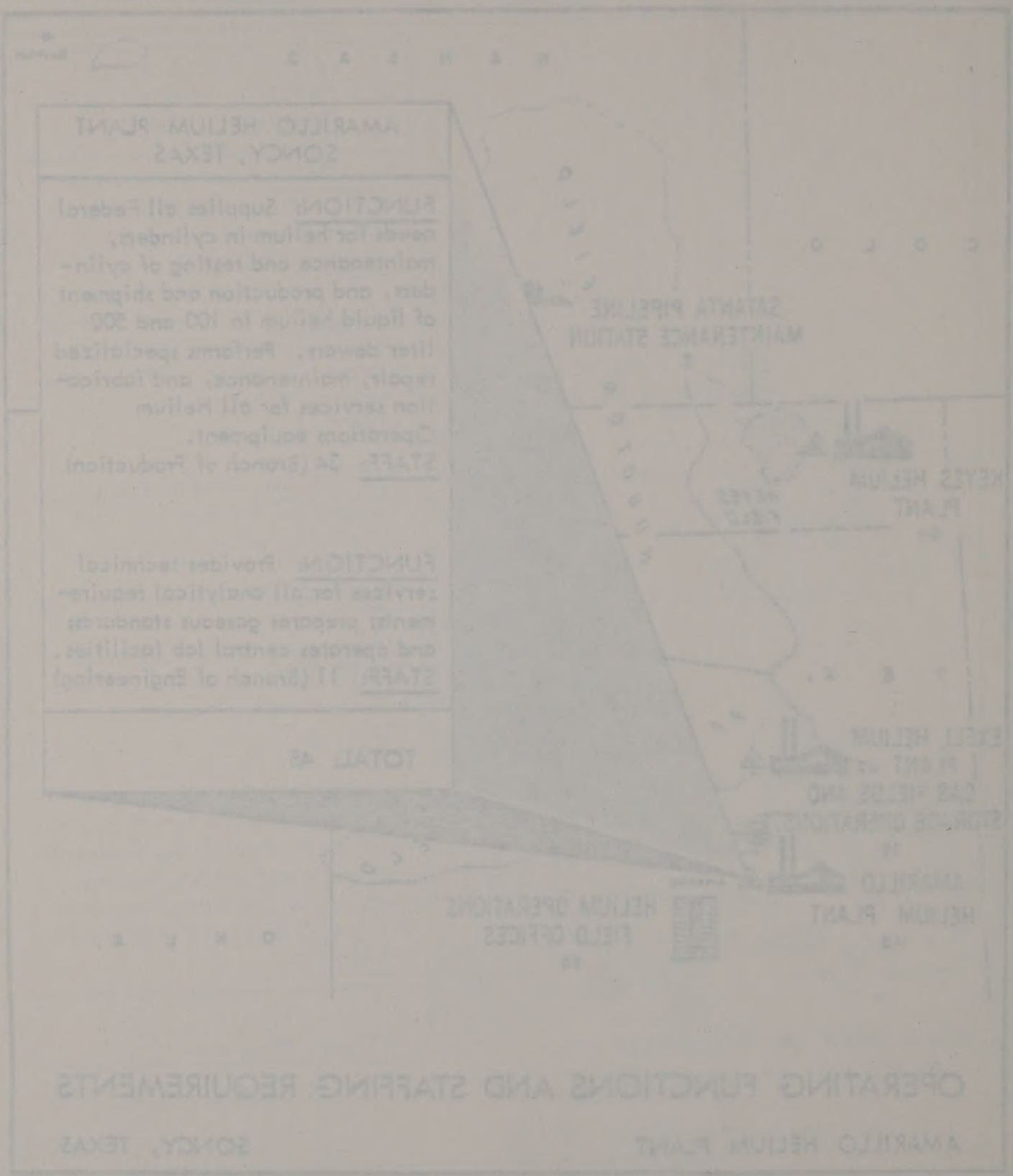


Figure 3 - Amarillo Plant



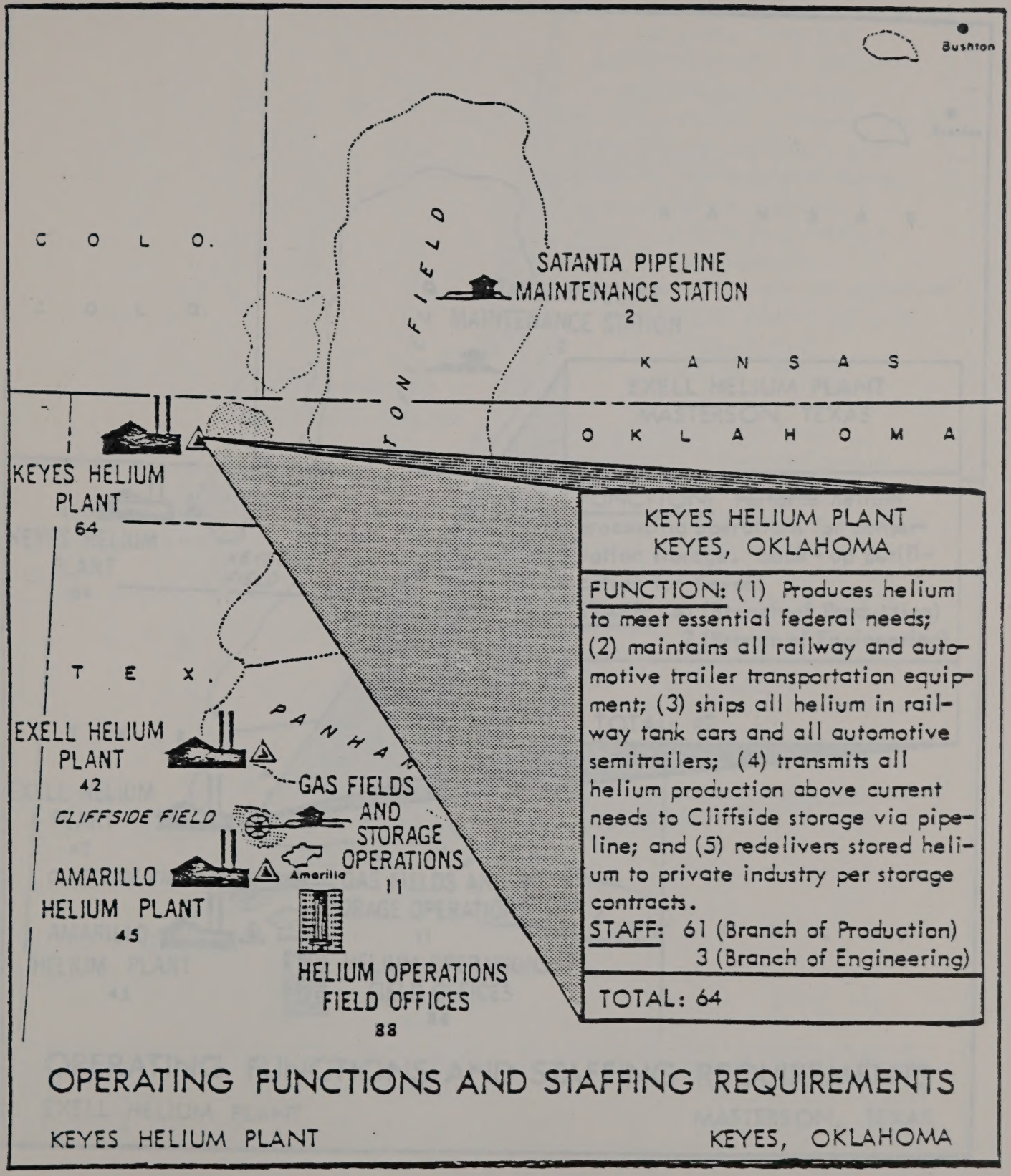
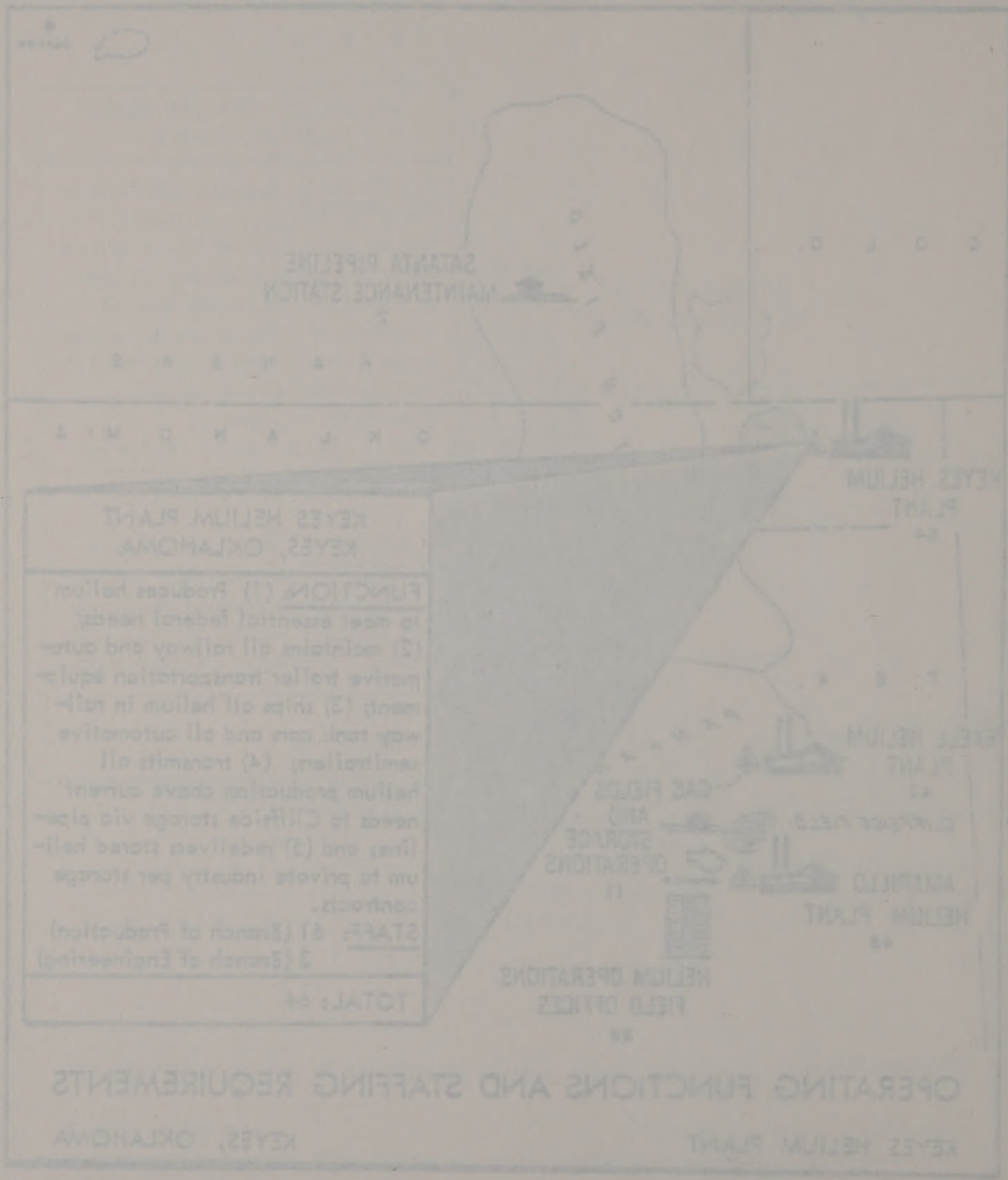


Figure 4 - Keyes Plant



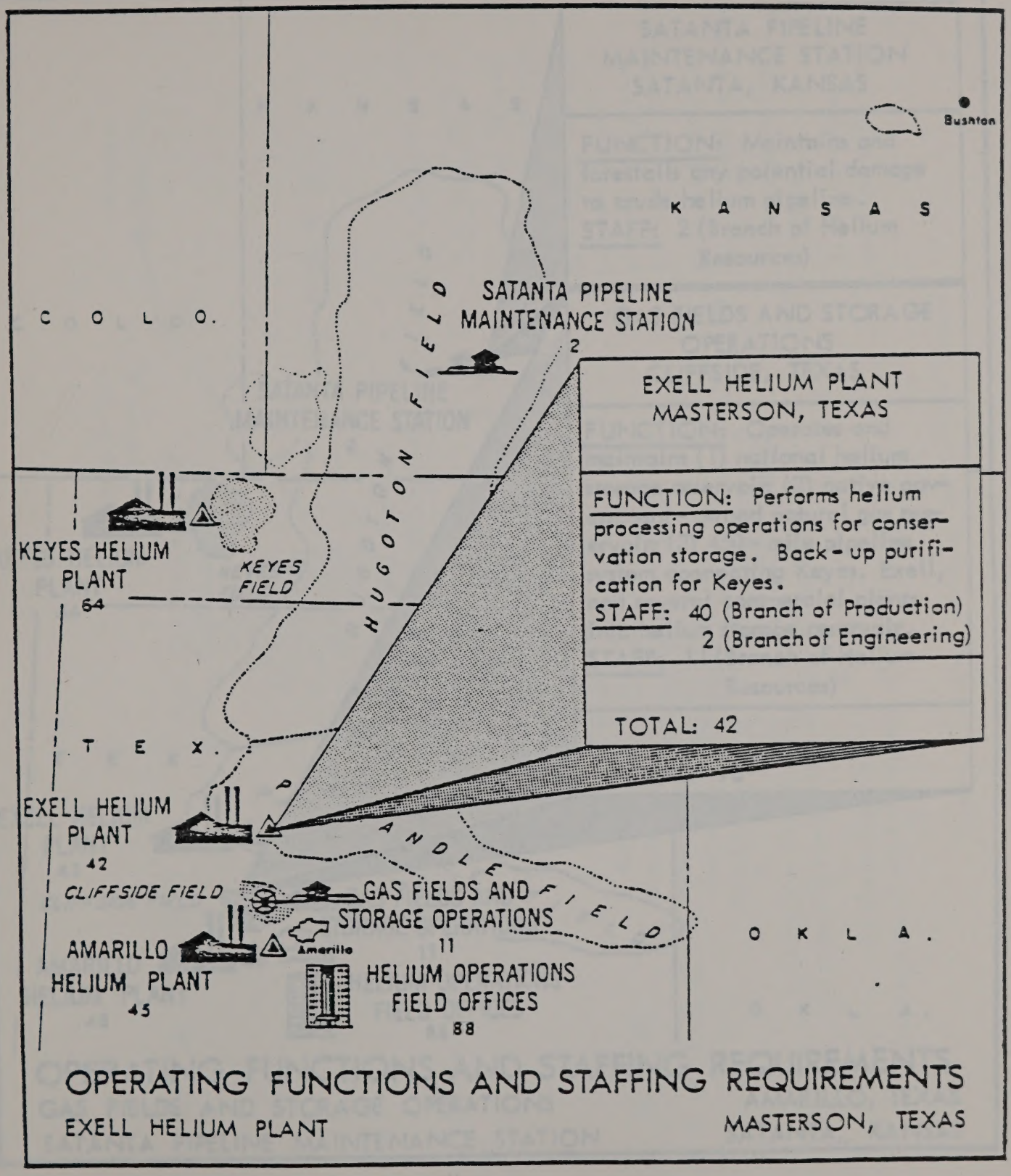
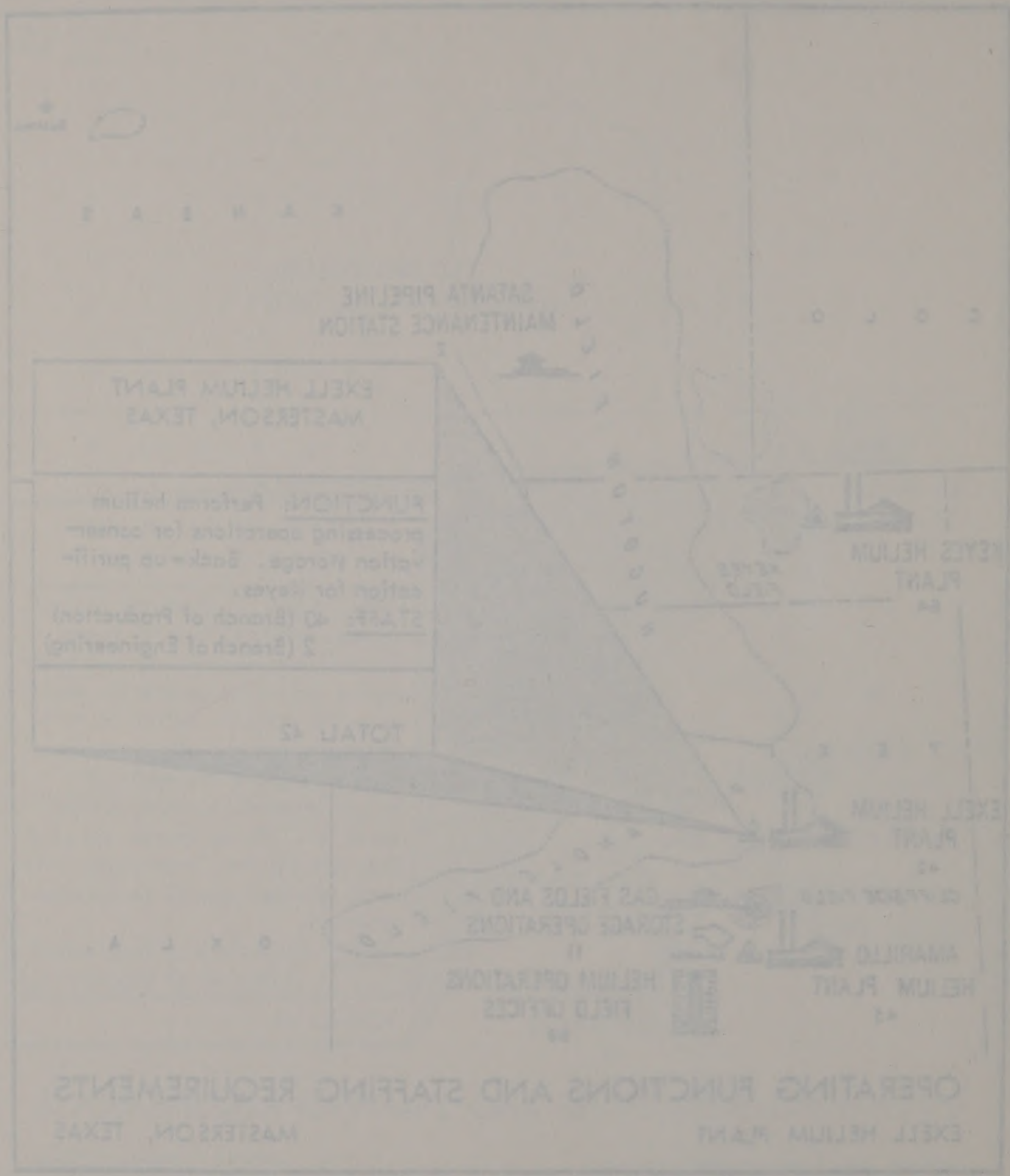


Figure 5 - Exell Plant



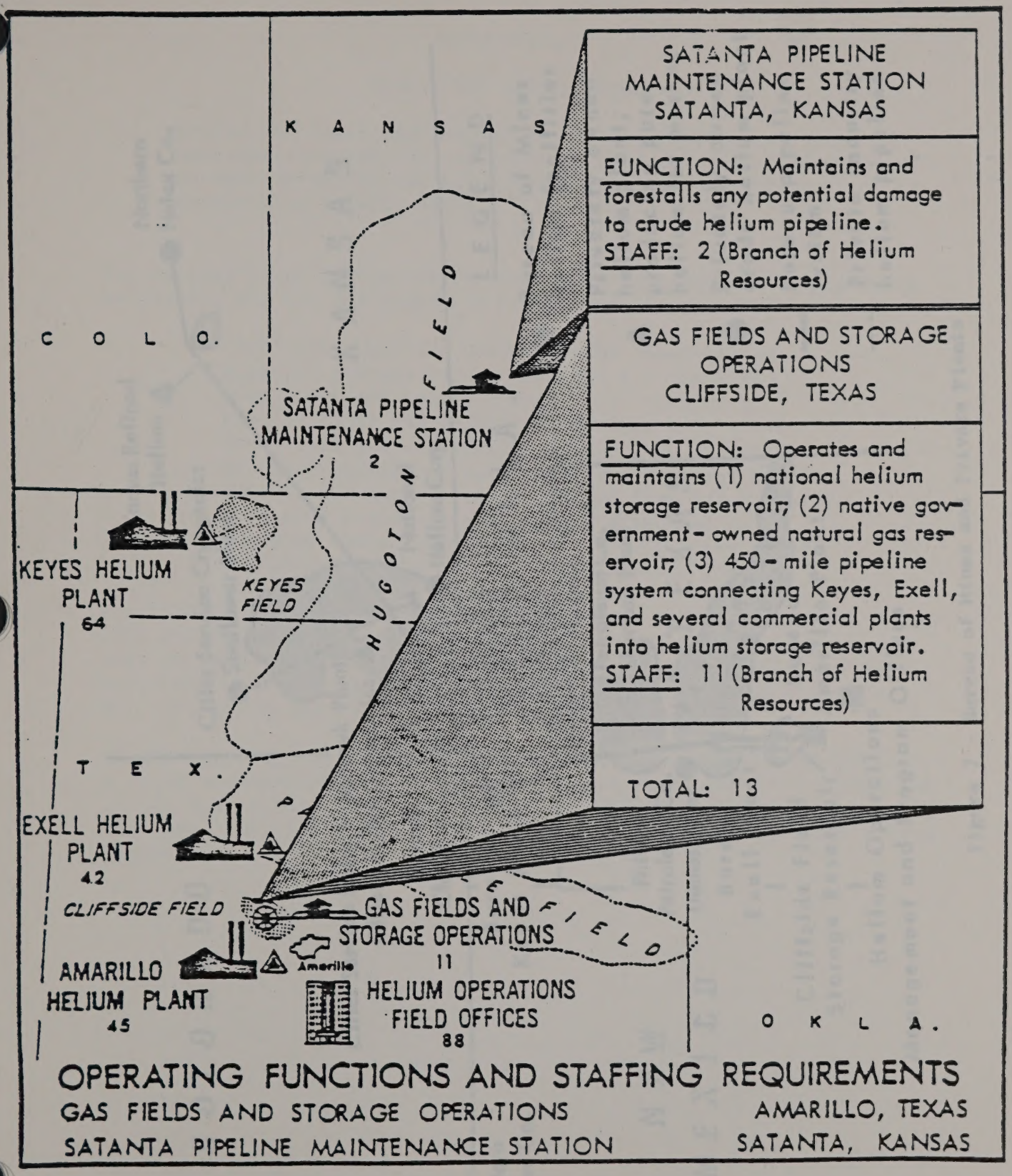
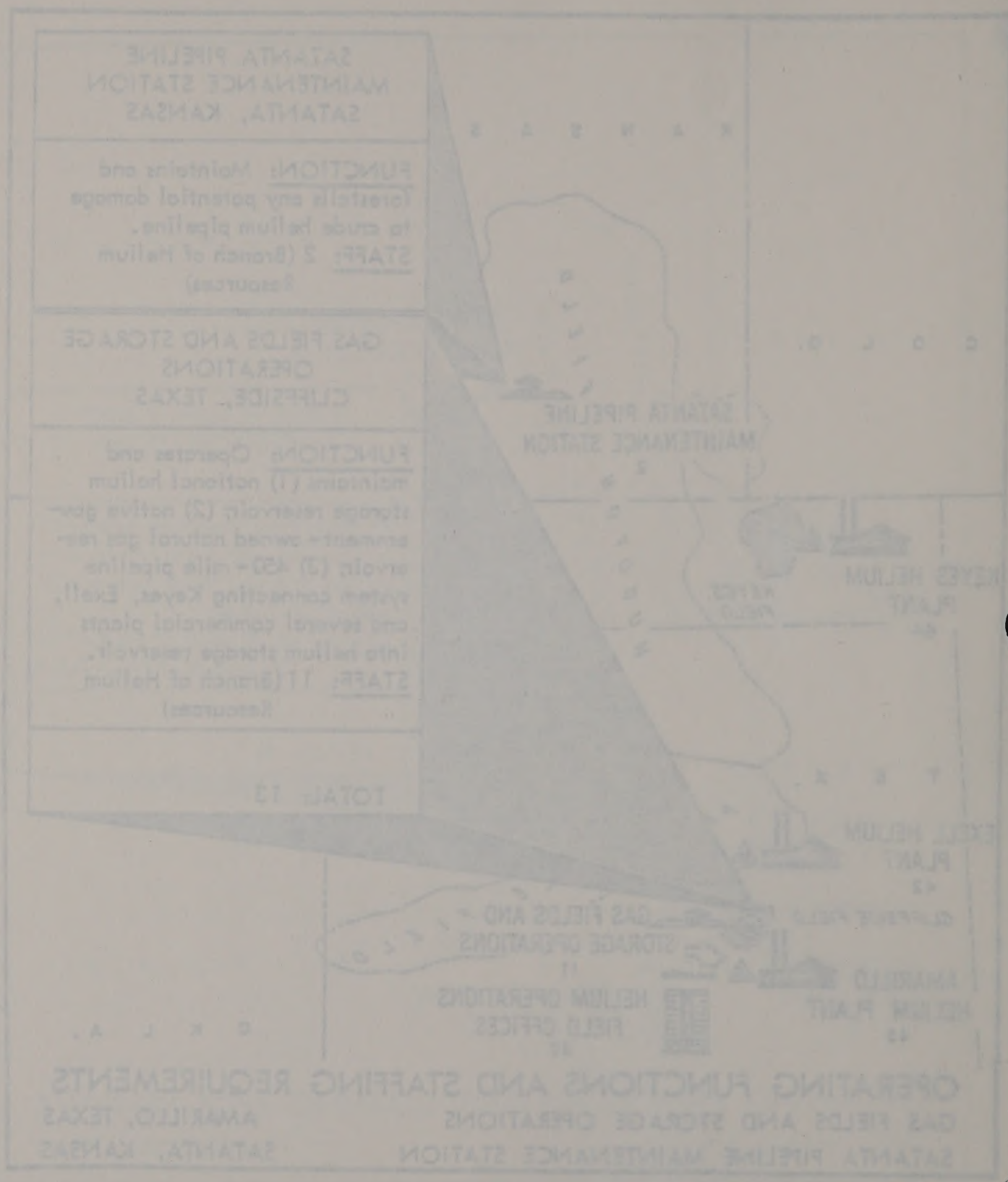

SATANTA PIPELINE MAINTENANCE STATION SATANTA, KANSAS
FUNCTION: Maintains and forestalls any potential damage to crude helium pipeline.
STAFF: 2 (Branch of Helium Resources)
GAS FIELDS AND STORAGE OPERATIONS CLIFFSIDE, TEXAS
FUNCTION: Operates and maintains (1) national helium storage reservoir; (2) native government-owned natural gas reservoir; (3) 450-mile pipeline system connecting Keyes, Exell, and several commercial plants into helium storage reservoir.
STAFF: 11 (Branch of Helium Resources)
TOTAL: 13
K A N S A S
C O L O.
HUGOTON FIELD
SATANTA PIPELINE MAINTENANCE STATION 2
KEYES HELIUM PLANT 64
KEYES FIELD
T E X.
EXELL HELIUM PLANT 42
CLIFFSIDE FIELD
GAS FIELDS AND STORAGE OPERATIONS 11
AMARILLO HELIUM PLANT 45
Amarillo
HELIUM OPERATIONS FIELD OFFICES 88
O K L A.
OPERATING FUNCTIONS AND STAFFING REQUIREMENTS
GAS FIELDS AND STORAGE OPERATIONS AMARILLO, TEXAS
SATANTA PIPELINE MAINTENANCE STATION SATANTA, KANSAS

Figure 6 - Cliffside and Satanta Facilities



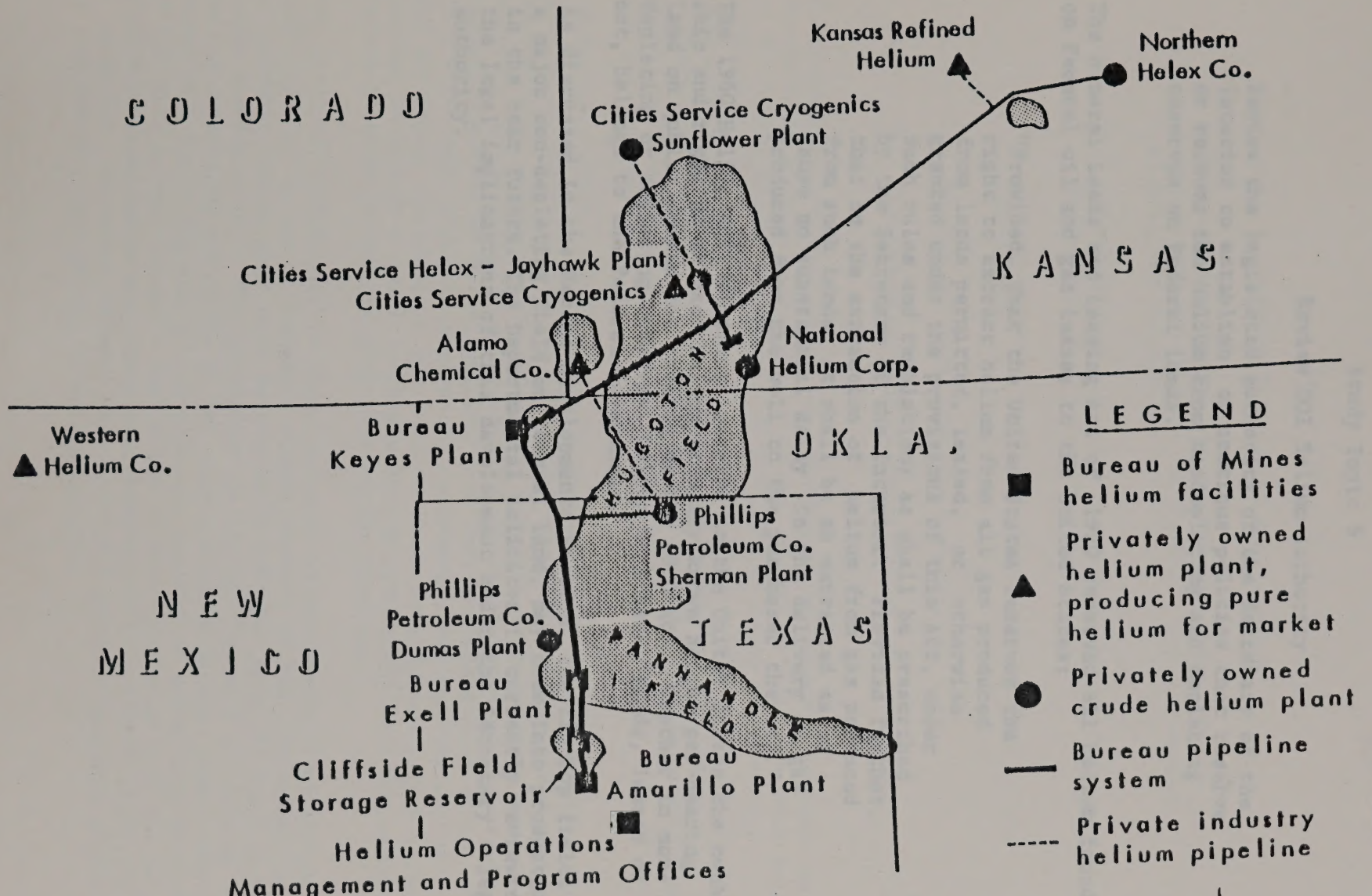


Figure 7 - Bureau of Mines and Private Plants

Study Topic 6

Review DOI Helium Authority

Review the legislated authority of the Secretary of the Interior to establish or continue policies that reserve or recover the helium from nondepleting and depleting reserves on Federal lands.

The Mineral Lands and Leasing Act of 1920 reserved all helium found on Federal oil and gas leases to the United States:

> "Provided, that the United States reserves the right to extract helium from all gas produced from lands permitted, leased, or otherwise granted under the provisions of this Act, under such rules and regulations as shall be prescribed by the Secretary of the Interior. Provided further, that in the extraction of helium from gas produced from such lands, it shall be so extracted as to cause no substantial delay in the delivery of gas produced from the well to the purchaser thereof."

The 1960 Helium Act amendments reserve to the United States the ownership and right to extract helium from any known helium gas-bearing land on public domain not covered by the 1920 Act. Whether in nondepleting or depleting reserves, helium on Federal lands, leased or not, belongs to the Federal Government.

As discussed in the Recent Developments Section, the Tip Top field, a major non-depleting field on Federal land, may come into production in the near future. The Departmental Solicitor is currently reviewing the legal implications of this development under the Secretary's legal authority.

Study Topic 7

Assess Technology and Research

Assess existing technology to determine the advantages of and to set priorities for possible basic research, including the following:

(a) Economic processes for recovering helium from gases with lean helium contents.

(b) Helium recovery from industrial gas production and LNG plants.

(c) Helium recovery from the atmosphere.

(d) Technologies that conserve helium.

The Interagency Helium Committee identified technology assessment and research as an area of future activity. Authority for such work exists in Section 4 of the Helium Act of 1960, which among other things authorizes the Secretary of the Interior to "...conduct or contract with public and private parties for experimentation and research to discover new helium supplies and to improve processes and methods of helium production, purification, transportation, liquefaction, storage, and utilization...."

Currently, Interior, through the Bureau of Mines, conducts a continuous program of analyzing samples of natural gas from new gas field discoveries worldwide to identify new sources of helium. Work is being done to evaluate the possibility of identifying helium-bearing gas reservoirs through analyses of gases evolving from near-surface ground water. For this work, very accurate analytical instruments and methods are necessary and are being developed by the Bureau. Some developmental work is being pursued to design a small, portable helium extraction unit for use at helium-bearing gas fields with short-lived reserves.

The level of expenditure on these projects is not expected to change significantly in the foreseeable future because of the over-abundance of economic helium that will be available for the next 20 years or more. Large expenditures by the government to conduct research to develop new helium extraction processes do not seem justified at this time. Moreover, there is a large private helium industry capable of doing such research, if and when a need arises. The Bureau of Mines plans to continue helium resources assessments and other experimentation as outlined above until a need for increased efforts is established through periodic studies of the Nation's helium supply/demand outlook.

Study Topic 8

Regular Review of Helium Position

> Having the Department of the Interior jointly examine with major Federal users (currently DOD, NASA, and DOE) any important changes in the status of the Nation's helium supply/demand situation, at least every 5 years.

The Bureau of Mines Helium Division regularly monitors domestic helium resources, reserves, and production capacity. Helium supply estimates compiled by the Bureau are continuously updated, as are production cost estimates from a wide range of gas streams. These estimates are based on natural gas reservoir and gas processing engineering studies which permit a relatively high degree of accuracy. In the future, the Bureau could improve its international coverage by emphasizing helium resource, reserve, production capacity, and supply/demand studies on a worldwide basis.

Demand estimates present a very different set of problems. The near-term demand for helium can be estimated with some accuracy on the basis of existing and announced private and government programs. Long-term demand depends on events and changes in technology that are very difficult to predict. As the government agencies that would participate in an interagency review group are engaged in research which could lead to significant changes in helium demand, regular exchanges of information and opinion would lead to an improved understanding of the likely future helium demand situation. Consideration should be given to inviting participants from the private helium industry in such exchanges.

Recent Development - The Tip Top Field

Of the total helium resources that are comingled with known natural gas, 85.3 Bcf are considered "nondepleting"; that is, they are located in gas fields that are not being produced or are not likely to be produced in the foreseeable future. Of this amount, 60 Bcf are located on Federal lands. According to a preliminary resource estimate made in 1974, about 44 Bcf of the Federally owned, nondepleting resources are in the Tip Top field in southwest Wyoming. This 1974 estimate indicates that the volume of all gases in Tip Top may exceed 5 trillion cubic feet (Table 22). Additional drilling may produce information that could significantly change this estimate.

Recently, Mobil Oil Corporation and Northwest Gas Pipeline Corporation announced plans to begin producing natural gas from the helium-rich deep zones of the Tip Top field by 1982 (Table 21).

Table 21
Tip Top Field Three Well Development Plan

August 1, 1978	- Spud first well
May 1 - May 30, 1979	- Test well potential
July 1, 1979	- Spud second well
April 1 - April 30, 1980	- Test well potential
June 1, 1980	- Spud third well
March 1 - March 30, 1981	- Test well potential
April 1, 1981 - December 31, 1981	- Processing plant construction
April 1, 1981 - 1990	- Field development drilling
January 1982	- Production start-up

The three-well development plan shown in Table 21 would permit production of about 40 million cubic feet per day of native gas at an annual rate of approximately 100 million cubic feet of helium per year. Tentative project plans include 27 wells and a production rate of 350 MMcfd. Should the 27-well program be completed, between 900 million and 1 billion cubic feet of helium per year would be available for up to 40 years. No firm date has been set for completion of the 27-well plan.

Table 22

Tip Top Field Resource Estimates *
(MMcf)

	Total Gas	Helium
Proved	778,860	6,127.5
Probable	4,882,478	38,486.7
Sum	5,661,338	44,614.2

* From D. M. Madden, Reserves and Geologic Study Helium Bearing Formations, Tip Top Unit, Sublette County, Wyoming; Fusselman, Winn, and Madden (Registered Professional Engineers), Casper, Wyoming, February 11, 1974.

The Tip Top field was considered nondepleting because the natural gas in the four deepest zones is mixed with significant amounts of carbon dioxide (CO_2), nitrogen, hydrogen sulfide (H_2S), and about 0.8% helium. As a result, its heating value averages only about 250 Btu. However, Northwest Gas Pipeline Corporation plans to build a non-cryogenic plant that will remove the CO_2 and H_2S but not the nitrogen and helium. The helium would simply be sent along with the methane, and released to the atmosphere when the gas is burned. This process produces a gas of about 730 Btu, which will be blended with higher Btu gas to achieve pipeline-quality gas. If the 27 well program is completed, the large flow rate of low Btu gas would require correspondingly large volumes of high-Btu gas for blending. If these volumes of gas are not available, it may also be necessary to remove the nitrogen and helium to obtain a higher quality gas.

The Department of the Interior is following Mobil-Northwest plans closely. Helium removal equipment could be installed in cooperation with these firms at several stages in the field development. Because this field contains not only 72% of Federal "nondepleting" resources, but also 53% of total U.S. nondepleting resources, Federal decisions concerning the Tip Top field warrant careful consideration. The Departmental Solicitor has begun a review of the legal implications of Tip Top development. The Bureau of Mines is investigating the problems associated with the Tip Top development.

APPENDIX A

U.S. Helium Resources: 1978-2000

Figure A-1: Potential Gas Committee Map

Table A-1: Projected Production of Helium and Natural Gas in the United States

Table A-2 through A-13: Projected Production of Helium and Natural Gas by PGC Area

Table A-14: Helium Content of Nondepleting Helium Resources in the United States

Figure A-1
Potential Gas Committee Map

Table A-1: Projected Production of Helium and Natural Gas in the United States

(All Volumes in Billion Cubic Feet @ 14.70 P.S.I.A. and 70° F)

Year	Gas Production From Proved Resources	Helium Contained in Produced Gas	Gas Production From Probable Resources	Helium Contained in Produced Gas	Gas Production From Proved and Probable Resources	Helium Contained in Produced Gas	Gas Production From Possible Resources	Helium Contained in Produced Gas	Gas Production From Proved Probable and Possible Resource	Helium Contained in Produced Gas	Gas Production From all Categories of Resources	Helium Contained in all Gas Production
1978	19607.	15.25	0.	0.00	19607.	15.25	0.	0.00	19607.	15.25	19607.	15.25
1979	19302.	15.01	0.	0.00	19302.	15.01	0.	0.00	19302.	15.01	19302.	15.01
1980	17132.	13.31	1829.	0.86	18962.	14.17	0.	0.00	18692.	14.17	18692.	14.17
1981	15139.	11.74	3456.	1.63	18595.	13.37	0.	0.00	18595.	13.37	18595.	13.37
1982	13449.	9.52	4878.	2.19	18327.	11.71	0.	0.00	18327.	11.71	18327.	11.71
1983	12004.	8.26	5995.	2.68	17999.	10.93	0.	0.00	17999.	10.93	17999.	10.93
1984	10761.	7.17	7011.	3.12	17772.	10.29	0.	0.00	17772.	10.29	17772.	10.29
1985	9687.	6.25	7722.	3.40	17409.	9.65	0.	0.00	17409.	9.65	17409.	9.65
1986	8752.	5.45	8536.	3.72	17288.	9.17	0.	0.00	17288.	9.17	17288.	9.17
1987	7935.	4.79	9145.	3.95	17081.	8.75	0.	0.00	17081.	8.75	17081.	8.75
1988	7218.	4.36	9552.	4.13	16770.	8.49	0.	0.00	16770.	8.49	16770.	8.49
1989	6585.	3.97	9959.	4.30	16544.	8.28	0.	0.00	16544.	8.28	16544.	8.28
1990	6026.	3.63	10162.	4.40	16188.	8.02	0.	0.00	16188.	8.02	16188.	8.02
1991	5528.	3.33	10366.	4.48	15894.	7.81	0.	0.00	15894.	7.81	15894.	7.81
1992	5084.	3.07	10569.	4.56	15653.	7.63	0.	0.00	15653.	7.63	15653.	7.63
1993	4687.	2.83	10671.	4.62	15358.	7.45	0.	0.00	15358.	7.45	15358.	7.45
1994	4330.	2.61	10874.	4.70	15204.	7.31	0.	0.00	15204.	7.31	15204.	7.31
1995	4010.	2.43	10243.	4.43	14254.	6.85	610.	0.29	14863.	7.16	14863.	7.16
1996	3720.	2.24	9236.	3.49	12956.	6.24	1624.	0.77	14581.	7.01	14581.	7.01
1997	3458.	2.09	8359.	3.62	11817.	5.71	2538.	1.22	14355.	6.93	14355.	6.93
1998	3170.	1.95	7589.	3.28	10759.	5.22	3554.	1.72	14314.	6.84	14314.	6.84
1999	3004.	1.82	6913.	2.99	9916.	4.80	3961.	1.91	13877.	6.71	13877.	6.71
2000	2807.	1.70	6315.	2.72	9122.	4.42	4570.	2.20	13691.	6.62	13691.	6.62

Table A-2: Projected Production of Helium and Natural Gas in PGC Area A

(All Volumes in Billion Cubic Feet @ 14.70 P.S.I.A. and 70° F)

Year	Gas Production From Proved Resources	Helium Contained in Produced Gas	Gas Production From Probable Resources	Helium Contained in Produced Gas	Gas Production From Proved and Probable Resources	Helium Contained in Produced Gas	Gas Production From Possible Resources	Helium Contained in Produced Gas	Gas Production From Proved Probable and Possible Resource	Helium Contained in Produced Gas	Gas Production From all Categories of Resources	Helium Contained in all Gas Production
1978	670.	0.63	0.	0.00	670.	0.63	0.	0.00	670.	0.63	670.	0.63
1979	660.	0.62	0.	0.00	660.	0.62	0.	0.00	660.	0.62	660.	0.62
1980	585.	0.55	238.	0.22	823.	0.77	0.	0.00	823.	0.77	823.	0.77
1981	516.	0.48	449.	0.42	965.	0.91	0.	0.00	965.	0.91	965.	0.91
1982	409.	0.38	599.	0.56	1008.	0.95	0.	0.00	1008.	0.95	1008.	0.95
1983	352.	0.33	727.	0.68	1079.	1.01	0.	0.00	1079.	1.01	1079.	1.01
1984	303.	0.28	840.	0.79	1142.	1.07	0.	0.00	1142.	1.07	1142.	1.07
1985	261.	0.25	912.	0.86	1173.	1.10	0.	0.00	1173.	1.10	1173.	1.10
1986	226.	0.21	995.	0.94	1221.	1.15	0.	0.00	1221.	1.15	1221.	1.15
1987	196.	0.18	1052.	0.99	1248.	1.17	0.	0.00	1248.	1.17	1248.	1.17
1988	178.	0.17	1099.	1.03	1277.	1.20	0.	0.00	1277.	1.20	1277.	1.20
1989	163.	0.15	1146.	1.08	1308.	1.23	0.	0.00	1308.	1.23	1308.	1.23
1990	149.	0.14	1169.	1.10	1318.	1.24	0.	0.00	1318.	1.24	1318.	1.24
1991	137.	0.13	1192.	1.12	1329.	1.25	0.	0.00	1329.	1.25	1329.	1.25
1992	126.	0.12	1216.	1.14	1341.	1.26	0.	0.00	1341.	1.26	1341.	1.26
1993	116.	0.11	1227.	1.15	1343.	1.26	0.	0.00	1343.	1.26	1343.	1.26
1994	107.	0.10	1251.	1.18	1358.	1.28	0.	0.00	1358.	1.28	1358.	1.28
1995	99.	0.09	1178.	1.11	1277.	1.20	15.	0.01	1292.	1.21	1292.	1.21
1996	92.	0.09	1062.	1.00	1154.	1.08	40.	0.04	1194.	1.12	1194.	1.12
1997	85.	0.08	961.	0.90	1047.	0.98	63.	0.06	1110.	1.04	1110.	1.04
1998	80.	0.07	873.	0.82	953.	0.90	88.	0.08	1040.	0.98	1040.	0.98
1999	74.	0.07	795.	0.75	869.	0.82	98.	0.09	967.	0.91	967.	0.91
2000	69.	0.07	726.	0.68	796.	0.75	113.	0.11	909.	0.85	909.	0.85

Table A-3: Projected Production of Helium and Natural Gas in PGC Area B

(All Volumes in Billion Cubic Feet @ 14.70 P.S.I.A. and 70° F)

Year	Gas Production From Proved Resources	Helium Contained in Produced Gas	Gas Production From Probable Resources	Helium Contained in Produced Gas	Gas Production From Proved and Probable Resources	Helium Contained in Produced Gas	Gas Production From Possible Resources	Helium Contained in Produced Gas	Gas Production From Proved Probable and Possible Resource	Helium Contained in Produced Gas	Gas Production From all Categories of Resources	Helium Contained in all Gas Producti
1978	209.	0.10	0.	0.00	209.	0.10	0.	0.00	209.	0.10	209.	0.10
1979	206.	0.09	0.	0.00	206.	0.09	0.	0.00	206.	0.09	206.	0.09
1980	183.	0.08	47.	0.02	230.	0.11	0.	0.00	230.	0.11	230.	0.11
1981	161.	0.07	89.	0.04	250.	0.12	0.	0.00	250.	0.12	250.	0.12
1982	128.	0.06	119.	0.05	247.	0.11	0.	0.00	247.	0.11	247.	0.11
1983	110.	0.05	145.	0.07	255.	0.12	0.	0.00	255.	0.12	255.	0.12
1984	94.	0.04	167.	0.08	262.	0.12	0.	0.00	262.	0.12	262.	0.12
1985	81.	0.04	182.	0.08	263.	0.12	0.	0.00	263.	0.12	263.	0.12
1986	70.	0.03	198.	0.09	269.	0.12	0.	0.00	269.	0.12	269.	0.12
1987	61.	0.03	210.	0.10	271.	0.12	0.	0.00	271.	0.12	271.	0.12
1988	56.	0.03	219.	0.10	275.	0.13	0.	0.00	275.	0.13	275.	0.13
1989	51.	0.02	228.	0.10	279.	0.13	0.	0.00	279.	0.13	279.	0.13
1990	46.	0.02	233.	0.11	279.	0.13	0.	0.00	279.	0.13	279.	0.13
1991	43.	0.02	238.	0.11	280.	0.13	0.	0.00	280.	0.13	280.	0.13
1992	39.	0.02	242.	0.11	281.	0.13	0.	0.00	281.	0.13	281.	0.13
1993	36.	0.02	245.	0.11	281.	0.13	0.	0.00	281.	0.13	281.	0.13
1994	33.	0.02	249.	0.11	283.	0.13	0.	0.00	283.	0.13	283.	0.13
1995	31.	0.01	235.	0.11	266.	0.12	10.	0.00	276.	0.13	276.	0.13
1996	29.	0.01	212.	0.10	240.	0.11	27.	0.01	267.	0.12	267.	0.12
1997	27.	0.01	192.	0.09	218.	0.10	42.	0.02	260.	0.12	260.	0.12
1998	25.	0.01	174.	0.08	199.	0.09	58.	0.03	257.	0.12	257.	0.12
1999	23.	0.01	158.	0.07	182.	0.08	65.	0.03	247.	0.11	247.	.11
2000	22.	0.01	145.	0.07	166.	0.08	75.	0.03	241.	0.11	241.	0.11

Table A-4: Projected Production of Helium and Natural Gas in PGC Area C

(All Volumes in Billion Cubic Feet @ 14.70 P.S.I.A. and 70° F)

Year	Gas Production From Proved Resources	Helium Contained in Produced Gas	Gas Production From Probable Resources	Helium Contained in Produced Gas	Gas Production From Proved and-Probable Resources	Helium Contained in Produced Gas	Gas Production From Possible Resources	Helium Contained in Produced Gas	Gas Production From Proved Probable and Possible Resource	Helium Contained in Produced Gas	Gas Production From all Categories of Resources	Helium Contained in all Gas Production
1978	209.	0.34	0.	0.00	209.	0.34	0.	0.00	209.	0.34	209.	0.34
1979	206.	0.33	0.	0.00	206.	0.33	0.	0.00	206.	0.33	206.	0.33
1980	183.	0.30	2.	0.00	185.	0.30	0.	0.00	185.	0.30	185.	0.30
1981	161.	0.26	4.	0.01	165.	0.27	0.	0.00	165.	0.27	165.	0.27
1982	128.	0.21	5.	0.01	133.	0.21	0.	0.00	133.	0.21	133.	0.21
1983	110.	0.18	6.	0.01	116.	0.19	0.	0.00	116.	0.19	116.	0.19
1984	94.	0.15	7.	0.01	102.	0.16	0.	0.00	102.	0.16	102.	0.16
1985	81.	0.13	8.	0.01	89.	0.14	0.	0.00	89.	0.14	89.	0.14
1986	70.	0.11	8.	0.01	79.	0.13	0.	0.00	79.	0.13	79.	0.13
1987	61.	0.10	9.	0.01	70.	0.11	0.	0.00	70.	0.11	70.	0.11
1988	56.	0.09	9.	0.02	65.	0.11	0.	0.00	65.	0.11	65.	0.11
1989	51.	0.08	10.	0.02	60.	0.10	0.	0.00	60.	0.10	60.	0.10
1990	46.	0.08	10.	0.02	56.	0.09	0.	0.00	56.	0.09	56.	0.09
1991	43.	0.07	10.	0.02	53.	0.09	0.	0.00	53.	0.09	53.	0.09
1992	39.	0.06	10.	0.02	49.	0.08	0.	0.00	49.	0.08	49.	0.08
1993	36.	0.06	10.	0.02	47.	0.08	0.	0.00	47.	0.08	47.	0.08
1994	33.	0.05	11.	0.02	44.	0.07	0.	0.00	44.	0.07	44.	0.07
1995	31.	0.05	10.	0.02	41.	0.07	7.	0.01	48.	0.08	48.	0.08
1996	29.	0.05	9.	0.01	38.	0.06	18.	0.03	56.	0.09	56.	0.09
1997	27.	0.04	8.	0.01	35.	0.06	28.	0.05	63.	0.10	63.	0.10
1998	25.	0.04	7.	0.01	32.	0.05	39.	0.06	71.	0.12	71.	0.12
1999	23.	0.04	7.	0.01	30.	0.05	44.	0.07	73.	0.12	73.	0.12
2000	22.	0.04	6.	0.01	28.	0.05	50.	0.08	78.	0.13	78.	0.13

Table A-5: Projected Production of Helium and Natural Gas in PGC Area D

(All Volumes in Billion Cubic Feet @ 14.70 P.S.I.A. and 70° F)

Year	Gas Production From Proved Resources	Helium Contained in Produced Gas	Gas Production From Probable Resources	Helium Contained in Produced Gas	Gas Production From Proved and Probable Resources	Helium Contained in Produced Gas	Gas Production From Possible Resources	Helium Contained in Produced Gas	Gas Production From Proved Probable and Possible Resource	Helium Contained in Produced Gas	Gas Production From all Categories of Resources	Helium Contained in all Gas Production
1978	1196.	0.82	0.	0.00	1196.	0.82	0.	0.00	1196.	0.82	1196.	0.82
1979	1177.	0.81	0.	0.00	1177.	0.81	0.	0.00	1177.	0.81	1177.	0.81
1980	1043.	0.72	76.	0.05	1119.	0.77	0.	0.00	1119.	0.77	1119.	0.77
1981	920.	0.63	143.	0.10	1063.	0.73	0.	0.00	1063.	0.73	1063.	0.73
1982	729.	0.50	191.	0.13	919.	0.63	0.	0.00	919.	0.63	919.	0.63
1983	627.	0.43	232.	0.16	859.	0.59	0.	0.00	859.	0.59	859.	0.59
1984	540.	0.37	267.	0.18	807.	0.56	0.	0.00	807.	0.56	807.	0.56
1985	465.	0.32	291.	0.20	756.	0.52	0.	0.00	756.	0.52	756.	0.52
1986	402.	0.28	317.	0.22	719.	0.50	0.	0.00	719.	0.50	719.	0.50
1987	349.	0.24	335.	0.23	684.	0.47	0.	0.00	684.	0.47	684.	0.47
1988	318.	0.22	350.	0.24	668.	0.46	0.	0.00	668.	0.46	668.	0.46
1989	290.	0.20	365.	0.25	655.	0.45	0.	0.00	655.	0.45	665.	0.45
1990	265.	0.18	372.	0.26	638.	0.44	0.	0.00	638.	0.44	638.	0.44
1991	243.	0.17	380.	0.26	623.	0.43	0.	0.00	623.	0.43	623.	0.43
1992	224.	0.15	387.	0.27	611.	0.42	0.	0.00	611.	0.42	611.	0.42
1993	206.	0.14	391.	0.27	597.	0.41	0.	0.00	597.	0.41	597.	0.41
1994	191.	0.13	398.	0.27	589.	0.41	0.	0.00	589.	0.41	589.	0.41
1995	177.	0.12	375.	0.26	552.	0.38	35.	0.02	587.	0.41	587.	0.41
1996	164.	0.11	338.	0.23	502.	0.35	94.	0.06	596.	0.41	596.	0.41
1997	152.	0.11	306.	0.21	458.	0.32	147.	0.10	605.	0.42	605.	0.42
1998	142.	0.10	278.	0.19	420.	0.29	205.	0.14	625.	0.43	625.	0.43
1999	132.	0.09	253.	0.17	385.	0.27	229.	0.16	614.	0.42	614.	0.42
2000	124.	0.09	231.	0.16	355.	0.24	264.	0.18	619.	0.43	619.	0.43

Table A-6: Projected Production of Helium and Natural Gas in PGC Area E

(All Volumes in Billion Cubic Feet @ 14.70 P.S.I.A. and 70° F)

Year	Gas Production From Proved Resources	Helium Contained in Produced Gas	Gas Production From Probable Resources	Helium Contained in Produced Gas	Gas Production From Proved and Probable Resources	Helium Contained in Produced Gas	Gas Production From Possible Resources	Helium Contained in Produced Gas	Gas Production From Proved Probable and Possible Resource	Helium Contained in Produced Gas	Gas Production From all Categories of Resources	Helium Contained in all Gas Production
1978	5795.	0.23	0.	0.00	5795.	0.23	0.	0.00	5795.	0.23	5795.	0.23
1979	5704.	0.23	0.	0.00	5704.	0.23	0.	0.00	5704.	0.23	5704.	0.23
1980	5055.	0.20	467.	0.02	5522.	0.22	0.	0.00	5522.	0.22	5522.	0.22
1981	4460.	0.18	882.	0.04	5341.	0.21	0.	0.00	5341.	0.21	5341.	0.21
1982	3532.	0.14	1177.	0.05	4709.	0.19	0.	0.00	4709.	0.19	4709.	0.19
1983	3039.	0.12	1428.	0.06	4468.	0.18	0.	0.00	4468.	0.18	4468.	0.18
1984	2616.	0.10	1649.	0.07	4265.	0.17	0.	0.00	4265.	0.17	4265.	0.17
1985	2256.	0.09	1792.	0.07	4048.	0.16	0.	0.00	4048.	0.16	4048.	0.16
1986	1951.	0.08	1954.	0.08	3905.	0.16	0.	0.00	3905.	0.16	3905.	0.16
1987	1694.	0.07	2066.	0.08	3759.	0.15	0.	0.00	3759.	0.15	3759.	0.15
1988	1540.	0.06	2158.	0.09	3698.	0.15	0.	0.00	3698.	0.15	3698.	0.15
1989	1406.	0.06	2250.	0.09	3656.	0.15	0.	0.00	3656.	0.15	3656.	0.15
1990	1286.	0.05	2296.	0.09	3582.	0.14	0.	0.00	3582.	0.14	3582.	0.14
1991	1180.	0.05	2342.	0.09	3522.	0.14	0.	0.00	3522.	0.14	3522.	0.14
1992	1085.	0.04	2387.	0.10	3473.	0.14	0.	0.00	3473.	0.14	3473.	0.14
1993	1000.	0.04	2411.	0.10	3411.	0.14	0.	0.00	3411.	0.14	3411.	0.14
1994	924.	0.04	2456.	0.10	3381.	0.14	0.	0.00	3381.	0.14	3381.	0.14
1995	856.	0.03	2314.	0.09	3170.	0.13	116.	0.00	3286.	0.13	3286.	0.13
1996	794.	0.03	2086.	0.08	2880.	0.12	309.	0.01	3189.	0.13	3189.	0.13
1997	738.	0.03	1888.	0.08	2626.	0.11	483.	0.02	3109.	0.12	3109.	0.12
1998	688.	0.03	1714.	0.07	2402.	0.10	676.	0.03	3078.	0.12	3078.	0.12
1999	641.	0.03	1562.	0.06	2203.	0.09	753.	0.03	2956.	0.12	2956.	0.12
2000	399.	0.02	1427.	0.06	2026.	0.08	869.	0.03	2895.	0.12	2895.	0.12

Table A-7: Projected Production of Helium and Natural Gas in PGC Area G

(All Volumes in Billion Cubic Feet @ 14.70 P.S.I.A. and 70° F)

Year	Gas Production From Proved Resources	Helium Contained in Produced Gas	Gas Production From Probable Resources	Helium Contained in Produced Gas	Gas Production From Proved and Probable Resources	Helium Contained in Produced Gas	Gas Production From Possible Resources	Helium Contained in Produced Gas	Gas Production From Proved Probable and Possible Resource	Helium Contained in Produced Gas	Gas Production From all Categories of Resources	Helium Contained in all Gas Production
1978	3689.	0.18	0.	0.00	3689.	0.18	0.	0.00	3689.	0.18	3689.	0.18
1979	3631.	0.18	0.	0.00	3631.	0.18	0.	0.00	3631.	0.18	3631.	0.18
1980	3218.	0.16	372.	0.02	3590.	0.18	0.	0.00	3590.	0.18	3590.	0.18
1981	2839.	0.14	703.	0.04	3542.	0.18	0.	0.00	3542.	0.18	3542.	0.18
1982	2249.	0.11	938.	0.05	3187.	0.16	0.	0.00	3187.	0.16	3187.	0.16
1983	1935	0.10	1138.	0.06	3073.	0.15	0.	0.00	3073.	0.15	3073.	0.15
1984	1665	0.08	1314.	0.07	2980.	0.15	0.	0.00	2980.	0.15	2980.	0.15
1985	1436.	0.07	1428.	0.07	2864.	0.14	0.	0.00	2864.	0.14	2864.	0.14
1986	1242.	0.06	1558.	0.08	2799.	0.14	0.	0.00	2799.	0.14	2799.	0.14
1987	1078.	0.05	1647.	0.08	2725.	0.14	0.	0.00	2725.	0.14	2725.	0.14
1988	981.	0.05	1720.	0.09	2700.	0.14	0.	0.00	2700.	0.14	2700.	0.14
1989	895.	0.04	1793.	0.09	2688.	0.13	0.	0.00	2688.	0.13	2688.	0.13
1990	819.	0.04	1830.	0.09	2649.	0.13	0.	0.00	2649.	0.13	2649.	0.13
1991	751.	0.04	1866.	0.09	2618.	0.13	0.	0.00	2618.	0.13	2618.	0.13
1992	691.	0.03	1903.	0.10	2594.	0.13	0.	0.00	2594.	0.13	2594.	0.13
1993	637.	0.03	1921.	0.10	2558.	0.13	0.	0.00	2558.	0.13	2558.	0.13
1994	588.	0.03	1958.	0.10	2546.	0.13	0.	0.00	2546.	0.13	2546.	0.13
1995	545.	0.03	1845.	0.09	2390.	0.12	84.	0.00	2474.	0.12	2474.	0.12
1996	505.	0.03	1663.	0.08	2168.	0.11	224.	0.01	2392.	0.12	2392.	0.12
1997	470.	0.02	1505.	0.08	1975.	0.10	350.	0.02	2325.	0.12	2325.	0.12
1998	438.	0.02	1367.	0.07	1804.	0.09	490.	0.02	2294.	0.11	2294.	0.11
1999	408.	0.02	1245.	0.06	1653.	0.08	546.	0.03	2199.	0.11	2199.	0.11
2000	381.	0.02	1137.	0.06	1519.	0.08	630.	0.03	2148.	0.11	2148.	0.11

Table A-8: Projected Production of Helium and Natural Gas in PGC Area II

(All Volumes in Billion Cubic Feet @ 14.70 P.S.I.A. and 70° F)

Year	Gas Production From Proved Resources	Helium Contained in Produced Gas	Gas Production From Probable Resources	Helium Contained in Produced Gas	Gas Production From Proved and Probable Resources	Helium Contained in Produced Gas	Gas Production From Possible Resources	Helium Contained in Produced Gas	Gas Production From Proved Probable and Possible Resource	Helium Contained in Produced Gas	Gas Production From all Categories of Resources	Helium Contained in all Gas Production
1978	839.	0.87	0.	0.00	839.	0.87	0.	0.00	839.	0.87	839.	0.87
1979	826.	0.86	0.	0.00	826.	0.86	0.	0.00	826.	0.86	826.	0.86
1980	732.	0.76	143.	0.15	875.	0.91	0.	0.00	875.	0.91	875.	0.91
1981	646.	0.67	270.	0.28	916.	0.95	0.	0.00	916.	0.95	916.	0.95
1982	511	0.53	360.	0.37	872.	0.91	0.	0.00	872.	0.91	872.	0.91
1983	440.	0.46	437.	0.45	877.	0.91	0.	0.00	877.	0.91	877.	0.91
1984	379.	0.39	505.	0.53	884.	0.92	0.	0.00	884.	0.92	884.	0.92
1985	327.	0.34	549.	0.57	875.	0.91	0.	0.00	875.	0.91	875.	0.91
1986	282.	0.29	599.	0.62	881.	0.92	0.	0.00	881.	0.92	881.	0.92
1987	245.	0.25	633.	0.66	878.	0.91	0.	0.00	878.	0.91	878.	0.91
1988	223.	0.23	661.	0.69	884.	0.92	0.	0.00	884.	0.92	884.	0.92
1989	204.	0.21	689.	0.72	893.	0.93	0.	0.00	893.	0.93	893.	0.93
1990	186.	0.19	703.	0.73	889.	0.92	0.	0.00	889.	0.92	889.	0.92
1991	171.	0.18	717.	0.75	888.	0.92	0.	0.00	888.	0.92	888.	0.92
1992	157.	0.16	731.	0.76	888.	0.92	0.	0.00	888.	0.92	888.	0.92
1993	145.	0.15	738.	0.77	883.	0.92	0.	0.00	883.	0.92	883.	0.92
1994	134.	0.14	752.	0.78	886.	0.92	0.	0.00	886.	0.92	886.	0.92
1995	124.	0.13	709.	0.74	833.	0.87	52.	0.05	885.	0.92	885.	0.92
1996	115.	0.12	639.	0.66	754.	0.78	139.	0.14	893.	0.93	893.	0.93
1997	107.	0.11	578.	0.60	685.	0.71	217.	0.23	902.	0.94	902.	0.94
1998	100.	0.10	525.	0.55	625.	0.65	304.	0.32	929.	0.97	929.	0.97
1999	93.	0.10	478.	0.50	571.	0.59	339.	0.35	910.	0.95	910.	0.95
2000	87.	0.09	437.	0.45	524.	0.54	391.	0.41	915.	0.95	915.	0.95

Table A-9: Projected Production of Helium and Natural Gas in PGC Area I

(All Volumes in Billion Cubic Feet @ 14.70 P.S.I.A. and 70° F)

Year	Gas Production From Proved Resources	Helium Contained in Produced Gas	Gas Production From Probable Resources	Helium Contained in Produced Gas	Gas Production From Proved and Probable Resources	Helium Contained in Produced Gas	Gas Production From Possible Resources	Helium Contained in Produced Gas	Gas Production From Proved Probable and Possible Resource	Helium Contained in Produced Gas	Gas Production From all Categories of Resources	Helium Contained in all Gas Production
1978	839.	0.22	0.	0.00	839.	0.22	0.	0.00	839.	0.22	839.	0.22
1979	826.	0.21	0.	0.00	826.	0.21	0.	0.00	826.	0.21	826.	0.21
1980	732.	0.19	19.	0.00	751.	0.20	0.	0.00	751.	0.20	751.	0.20
1981	646.	0.17	36.	0.01	682.	0.18	0.	0.00	682.	0.18	682.	0.18
1982	511.	0.13	48.	0.01	559.	0.15	0.	0.00	559.	0.15	559.	0.15
1983	440.	0.11	58.	0.02	498.	0.13	0.	0.00	498.	0.13	498.	0.13
1984	379.	0.10	67.	0.02	446.	0.12	0.	0.00	446.	0.12	446.	0.12
1985	327.	0.08	73.	0.02	400.	0.10	0.	0.00	400.	0.10	400.	0.10
1986	282.	0.07	80.	0.02	362.	0.09	0.	0.00	362.	0.09	362.	0.09
1987	245.	0.06	84.	0.02	329.	0.09	0.	0.00	329.	0.09	329.	0.09
1988	223.	0.06	88.	0.02	311.	0.08	0.	0.00	311.	0.08	311.	0.08
1989	204.	0.05	92.	0.02	295.	0.08	0.	0.00	295.	0.08	295.	0.08
1990	186.	0.05	94.	0.02	280.	0.07	0.	0.00	280.	0.07	280.	0.07
1991	171.	0.04	95.	0.02	266.	0.07	0.	0.00	266.	0.07	266.	0.07
1992	157.	0.04	97.	0.03	254.	0.07	0.	0.00	254.	0.07	254.	0.07
1993	145.	0.04	98.	0.03	243.	0.06	0.	0.00	243.	0.06	243.	0.06
1994	134.	0.03	100.	0.03	234.	0.06	0.	0.00	234.	0.06	234.	0.06
1995	124.	0.03	94.	0.02	218.	0.06	5.	0.00	223.	0.06	223.	0.06
1996	115.	0.03	85.	0.02	200.	0.05	13.	0.00	213.	0.06	213.	0.06
1997	107.	0.03	77.	0.02	184.	0.05	21.	0.01	205.	0.05	205.	0.05
1998	100.	0.03	70.	0.02	169.	0.04	29.	0.01	199.	0.05	199.	0.05
1999	93.	0.02	64.	0.02	156.	0.04	32.	0.01	189.	0.05	189.	0.05
2000	87.	0.02	58.	0.02	145.	0.04	37.	0.01	182.	0.05	182.	0.05

Table A-10: Projected Production of Helium and Natural Gas in PGC Area JN

(All Volumes in Billion Cubic Feet @ 14.70 P.S.I.A. and 70° F)

Year	Gas Production From Proved Resources	Helium Contained in Produced Gas	Gas Production From Probable Resources	Helium Contained in Produced Gas	Gas Production From Proved and Probable Resources	Helium Contained in Produced Gas	Gas Production From Possible Resources	Helium Contained in Produced Gas	Gas Production From Proved Probable and Possible Resource	Helium Contained in Produced Gas	Gas Production From all Categories of Resources	Helium Contained in all Gas Production
1978	3447.	10.89	0.	0.00	3447.	10.89	0.	0.00	3447.	10.89	3447.	10.89
1979	3393.	10.72	0.	0.00	3393.	10.72	0.	0.00	3393.	10.72	3393.	10.72
1980	3007.	9.50	257.	0.28	3263.	9.79	0.	0.00	3263.	9.79	3263.	9.79
1981	2652.	8.38	485.	0.54	3137.	9.92	0.	0.00	3137.	8.92	3137.	8.92
1982	2101.	6.64	647.	0.72	2748.	7.36	0.	0.00	2748.	7.36	2748.	7.36
1983	1808.	5.71	785.	0.87	2593.	6.58	0.	0.00	2593.	6.58	2593.	6.58
1984	1556.	4.92	906.	1.01	2462.	5.92	0.	0.00	2462.	5.92	2462.	5.92
1985	1342.	4.24	985.	1.09	2327.	5.33	0.	0.00	2327.	5.33	2327.	5.33
1986	1160.	3.67	1074.	1.19	2234.	4.86	0.	0.00	2234.	4.86	2234.	4.86
1987	1007.	3.18	1135.	1.26	2143.	4.44	0.	0.00	2143.	4.44	2143.	4.44
1988	916.	2.90	1186.	1.32	2102.	4.21	0.	0.00	2102.	4.21	2102.	4.21
1989	836.	2.64	1236.	1.37	2072.	4.01	0.	0.00	2072.	4.01	2072.	4.01
1990	765.	2.42	1262.	1.40	2027.	3.82	0.	0.00	2027.	3.82	2027.	3.82
1991	702.	2.22	1287.	1.43	1989.	3.65	0.	0.00	1989.	3.65	1989.	3.65
1992	645.	2.04	1312.	1.46	1958.	3.50	0.	0.00	1958.	3.50	1958.	3.50
1993	595.	1.88	1325.	1.47	1920.	3.35	0.	0.00	1920.	3.35	1920.	3.35
1994	550.	1.74	1350.	1.50	1900.	3.24	0.	0.00	1900.	3.24	1900.	3.24
1995	509.	1.61	1275.	1.41	1781.	3.02	121.	0.13	1902.	3.15	1902.	3.15
1996	472.	1.49	1147.	1.27	1619.	2.76	322.	0.36	1941.	3.12	1941.	3.12
1997	439.	1.39	1038.	1.15	1477.	2.54	504.	0.56	1980.	3.10	1980.	3.10
1998	409.	1.29	942.	1.05	1351.	2.34	705.	0.78	2056.	3.12	2056.	3.12
1999	381.	1.20	858.	0.95	1240.	2.16	786.	0.87	2026.	3.03	2026.	3.03
2000	356.	1.13	784.	0.87	1140.	2.00	907.	1.01	2047.	3.00	2047.	3.00

Table A-11: Projected Production of Helium and Natural Gas in PGC Area JS

(All Volumes in Billion Cubic Feet @ 14.70 P.S.I.A. and 70° F)

Year	Gas Production From Proved Resources	Helium Contained in Produced Gas	Gas Production From Probable Resources	Helium Contained in Produced Gas	Gas Production From Proved and Probable Resources	Helium Contained in Produced Gas	Gas Production From Possible Resources	Helium Contained in Produced Gas	Gas Production From Proved Probable and Possible Resource	Helium Contained in Produced Gas	Gas Production From all Categories of Resources	Helium Contained in all Gas Production
1978	1918.	0.90	0.	0.00	1918.	0.90	0.	0.00	1918.	0.90	1918.	0.90
1979	1888.	0.89	0.	0.00	1888.	0.89	0.	0.00	1888.	0.89	1888.	0.89
1980	1673.	0.79	171.	0.08	1845.	0.87	0.	0.00	1845.	0.87	1845.	0.87
1981	1476.	0.69	324.	0.15	1800.	0.85	0.	0.00	1800.	0.85	1800.	0.85
1982	1169.	0.55	432.	0.20	1601.	0.75	0.	0.00	1601.	0.75	1601.	0.75
1983	1006.	0.47	524.	0.25	1530.	0.72	0.	0.00	1530.	0.72	1530.	0.72
1984	866.	0.41	605.	0.28	1471.	0.69	0.	0.00	1471.	0.69	1471.	0.69
1985	747.	0.35	658.	0.31	1404.	0.66	0.	0.00	1404.	0.66	1404.	0.66
1986	646.	0.30	717.	0.34	1363.	0.64	0.	0.00	1363.	0.64	1363.	0.64
1987	561.	0.26	758.	0.36	1319.	0.62	0.	0.00	1319.	0.62	1319.	0.62
1988	510.	0.24	792.	0.37	1302.	0.61	0.	0.00	1302.	0.61	1302.	0.61
1989	465.	0.22	826.	0.39	1291.	0.61	0.	0.00	1291.	0.61	1291.	0.61
1990	426.	0.20	843.	0.40	1268.	0.60	0.	0.00	1268.	0.60	1268.	0.60
1991	391.	0.18	859.	0.40	1250.	0.59	0.	0.00	1250.	0.59	1250.	0.59
1992	359.	0.17	876.	0.41	1235.	0.58	0.	0.00	1235.	0.58	1235.	0.58
1993	331.	0.16	885.	0.42	1216.	0.57	0.	0.00	1216.	0.57	1216.	0.57
1994	306.	0.14	902.	0.42	1207.	0.57	0.	0.00	1207.	0.57	1207.	0.57
1995	283.	0.13	849.	0.40	1133.	0.53	62.	0.03	1195.	0.56	1195.	0.56
1996	263.	0.12	766.	0.36	1029.	0.48	166.	0.08	1194.	0.56	1194.	0.56
1997	244.	0.11	693.	0.33	937.	0.44	259.	0.12	1196.	0.56	1196.	0.56
1998	228.	0.11	629.	0.30	857.	0.40	362.	0.17	1219.	0.57	1219.	0.57
1999	212.	0.10	573.	0.27	785.	0.37	404.	0.19	1189.	0.56	1189.	0.56
2000	198.	0.09	524.	0.25	722.	0.34	466.	0.22	1188.	0.56	1188.	0.56

Table A-12: Projected Production of Helium and Natural Gas in PGC Area K

(All Volumes in Billion Cubic Feet @ 14.70 P.S.I.A and 70° F)

Year	Gas Production From Proved Resources	Helium Contained in Produced Gas	Gas Production From Probable Resources	Helium Contained in Produced Gas	Gas Production From Proved, and Probable Resources	Helium Contained in Produced Gas	Gas Production From Possible Resources	Helium Contained in Produced Gas	Gas Production From Proved Probable and Possible Resource	Helium Contained in Produced Gas	Gas Production From all Categories of Resources	Helium Contained in all Gas Production
1978	229.	0.03	0.	0.00	229.	0.03	0.	0.00	229.	0.03	229.	0.03
1979	229.	0.03	0.	0.00	229.	0.03	0.	0.00	229.	0.03	229.	0.03
1980	229.	0.03	0.	0.00	229.	0.03	0.	0.00	229.	0.03	229.	0.03
1981	229.	0.03	0.	0.00	229.	0.03	0.	0.00	229.	0.03	229.	0.03
1982	1638.	0.24	266.	0.03	1905.	0.27	0.	0.00	1905.	0.27	1905.	0.27
1983	1841.	0.27	398.	0.05	2056.	0.33	0.	0.00	2056.	0.33	2056.	0.33
1984	2014.	0.30	550.	0.08	2564.	0.39	0.	0.00	2564.	0.39	2564.	0.39
1985	2143.	0.33	700.	0.10	2843.	0.43	0.	0.00	2843.	0.43	2843.	0.43
1986	2230.	0.34	878.	0.12	3107.	0.46	0.	0.00	3107.	0.46	3107.	0.46
1987	2272.	0.35	1049.	0.15	3322.	0.50	0.	0.00	3322.	0.50	3322.	0.50
1988	2067.	0.31	1096.	0.16	3163.	0.48	0.	0.00	3163.	0.48	3163.	0.48
1989	1885.	0.28	1143.	0.16	3028.	0.45	0.	0.00	3028.	0.45	3028.	0.45
1990	1726.	0.25	1166.	0.17	2892.	0.43	0.	0.00	2892.	0.43	2892.	0.43
1991	1583.	0.23	1090.	0.17	2772.	0.41	0.	0.00	2772.	0.41	2772.	0.41
1992	1456.	0.21	1213.	0.17	2669.	0.39	0.	0.00	2669.	0.39	2669.	0.39
1993	1342.	0.20	1224.	0.18	2566.	0.39	0.	0.00	2566.	0.39	2566.	0.39
1994	1240.	0.18	1247.	0.18	2488.	0.37	0.	0.00	2488.	0.37	2488.	0.37
1995	1148.	0.17	1175.	0.17	2323.	0.35	76.	0.01	2399.	0.38	2399.	0.38
1996	1066.	0.16	1059.	0.15	2125.	0.31	201.	0.02	2326.	0.34	2326.	0.34
1997	990.	0.15	959.	0.14	1949.	0.29	314.	0.04	2263.	0.34	2263.	0.34
1998	922.	0.14	871.	0.12	1793.	0.26	440.	0.06	2233.	0.33	2233.	0.33
1999	860.	0.13	792.	0.11	1653.	0.24	491.	0.07	2143.	0.31	2143.	0.31
2000	805.	0.12	724.	0.10	1528.	0.22	566.	0.08	2094.	0.30	2094.	0.30

Table A-13: Projected Production of Helium and Natural Gas in PGC Area L

(All Volumes in Billion Cubic Feet @ 14.70 P.S.I.A. and 70° F)

Year	Gas Production From Proved Resources	Helium Contained in Produced Gas	Gas Production From Probable Resources	Helium Contained in Produced Gas	Gas Production From Proved and Probable Resources	Helium Contained in Produced Gas	Gas Production From Possible Resources	Helium Contained in Produced Gas	Gas Production From Proved Probable and Possible Resource	Helium Contained in Produced Gas	Gas Production From all Categories of Resources	Helium Contained in all Gas Production
1978	566.	0.03	0.	0.00	566.	0.03	0.	0.00	566.	0.03	566.	0.03
1979	557.	0.03	0.	0.00	557.	0.03	0.	0.00	557.	0.03	557.	0.03
1980	494.	0.02	38.	0.00	531.	0.03	0.	0.00	531.	0.03	531.	0.03
1981	435.	0.02	71.	0.00	507.	0.03	0.	0.00	507.	0.03	507.	0.03
1982	345.	0.02	95.	0.00	440.	0.02	0.	0.00	440.	0.02	440.	0.02
1983	297.	0.01	116.	0.01	413.	0.02	0.	0.00	413.	0.02	413.	0.02
1984	255.	0.01	134.	0.01	389.	0.02	0.	0.00	389.	0.02	389.	0.02
1985	220.	0.01	145.	0.01	366.	0.02	0.	0.00	366.	0.02	366.	0.02
1986	190.	0.01	158.	0.01	349.	0.02	0.	0.00	349.	0.02	349.	0.02
1987	165.	0.01	168.	0.01	333.	0.02	0.	0.00	333.	0.02	333.	0.02
1988	150.	0.01	175.	0.01	325.	0.02	0.	0.00	325.	0.02	325.	0.02
1989	137.	0.01	182.	0.01	320.	0.02	0.	0.00	320.	0.02	320.	0.02
1990	126.	0.01	186.	0.01	312.	0.02	0.	0.00	312.	0.02	312.	0.02
1991	115.	0.01	190.	0.01	305.	0.02	0.	0.00	305.	0.02	305.	0.02
1992	106.	0.01	194.	0.01	300.	0.01	0.	0.00	300.	0.01	300.	0.01
1993	98.	0.00	195.	0.01	293.	0.01	0.	0.00	293.	0.01	293.	0.01
1994	90.	0.00	199.	0.01	289.	0.01	0.	0.00	289.	0.01	289.	0.01
1995	84.	0.00	188.	0.01	271.	0.01	27.	0.00	298.	0.01	298.	0.01
1996	78.	0.00	169.	0.01	247.	0.01	72.	0.00	318.	0.02	318.	0.02
1997	72.	0.00	153.	0.01	225.	0.01	112.	0.01	337.	0.02	337.	0.02
1998	67.	0.00	139.	0.01	206.	0.01	157.	0.01	363.	0.02	363.	0.02
1999	63.	0.00	127.	0.01	189.	0.01	175.	0.01	364.	0.02	364.	0.02
2000	58.	0.00	116.	0.01	174.	0.01	202.	0.01	376.	0.02	376.	0.02

TABLE A-14: Helium content of nondepleted helium resources of the United States
MMcf at 14.7 psia and 70° F as of January 1, 1977

State	Field	Reservior	Average Helium Content	Depth Feet	Area Acres	Reserves	
						Natural Gas	Helium
Kansas	Loretta	Arbuckle	7.02	3,521	840	968	54
Utah	Harley Dome	Entrada	7.01	860	453	1,584	110
New Mexico	Table Mesa, South	Mississippian	6.14	7,490	640	401	24
Arizona	Teec Nos Pos	Mississippian	5.99	6,295	-	711	42
New Mexico	Table Mesa, South	Paradox	5.70	7,092	640	309	17
Kansas	Hungry Hollow	Arbuckle	5.66	3,478	790	766	53
Arizona	Dineh bi Keyah	McCracken	5.16	4,143	41,829	144,058	7,566
Arizona	East Boundary Butte	Mississippian	3.79	5,570	640	2,077	79
Kansas	Churchview	Mississippian	3.25	4,502	480	1,887	60
Utah	Temple Springs	Devonian	2.80	4,642	540	3,774	105
Kansas	Reginer	Osage	2.38	4,604	-	1,858	44
Colorado	Moore "A" 1-24	Red Cave	2.14	1,214	640	3,305	71
Kansas	Badger Hill	Cherokee	2.04	4,375	1,779	4,835	98
Texas	Cliffside	Brown Dolomite	1.86	3,300	11,000	206,323	3,837
Utah	Boundary Butte, N	Ouray	1.58	5,868	640	8,886	140
Utah	Big Flat	Mississippian	1.55	7,590	484	4,109	63
Utah	Bow Knot	Mississippian	1.47	6,250	1,347	14,008	206
Utah	Bartlett Flat	Mississippian	1.40	7,390	611	13,001	181
Utah	Long Canyon	Mississippian	1.37	7,640	1,984	14,168	194
Montana	Rudyard	Red River	1.30	5,203	10,600	160,091	2,081
Montana	Howard Coulee	Madison	1.16	5,055	876	14,639	169
Utah	Lisbon	Mississippian	1.00	8,100	3,219	176,850	1,768
Montana	Rudyard	Souris River	0.90	5,068	10,600	73,627	662
Wyoming	Tip Top[1/]	Big Horn	0.90	15,052	1,823	243,314	2,190
Colorado	Baxter Pass, South	Morrison	0.85	6,446	800	8,415	71
Colorado	Douglas Creek, South	Morrison	0.80	5,430	1,715	4,864	38
Wyoming	Tip Top[1/]	Tensleep	0.80	12,902	7,533	1,071,470	8,571
Wyoming	Tip Top[1/]	Madison	0.78	13,783	22,779	4,421,829	34,489

1/ Mobil Oil Company plans production in 1981-82.

TABLE A-14: Helium content of nonde[illegible]g helium resources of the United States (con.)
MMcf at 14.7 psia and 70° F as of January 1, 1977

State	Field	Reservior	Average Helium Content	Depth Feet	Area Acres	Reserves Natural Gas	Reserves Helium
Colorado	Doe Canyon	Mississippian	0.76	8,520	640	47,371	359
Colorado	Douglas Creek, South	Buckhorn	0.75	5,127	7,635	41,438	310
Colorado	Douglas Creek, South	Dakota	0.70	5,019	3,667	14,808	103
Colorado	Baxter Pass	Dakota	0.70	6,311	640	7,745	53
Texas	Cliffside	Red Cave	0.64	2,550	2,680	5,047	32
Utah	Baxter Basin, North	Morgan	0.64	7,500	200	2,077	13
Utah	Little Valley	Mississippian	0.56	9,200	255	2,173	12
New Mexico	Ute Dome	Mississippian	0.55	9,394	640	160,496	882
Utah	Federal Mounds	Mississippian	0.55	8,350	640	75,898	409
Utah	Clay Basin	Weber	0.48	9,025	3,095	125,600	602
Wyoming	Tip Top 1/	Phosphoria	0.48	12,604	1,004	14,172	68
Wyoming	Baxter Basin, North	Weber	0.43	6,200	1,130	41,424	177
West Virginia	Parson	Tuscarora	0.43	7,020	5,000	27,832	119
Montana	Cabin Creek	Cambrian	0.40	10,086	1,375	36,624	146
Utah	Bluff Unit	Ouray	0.40	6,940	1,280	41,638	168
Wyoming	Table Rock 2/	Madison	0.285	18,368	3,840	300,000	869
Wyoming	Church Buttes	Madison	0.24	18,318	40,394	7,330,454	17,592
Wyoming	Butcherknife Springs	Morgan	0.18	18,200	7,360	38,701	67
Total							84,964

1/ Mobil Oil Company plans production in 1981-82.
2/ Table Rock field now depleting.

APPENDIX B
Estimated Costs of Producing Nondepleting Reserves

The costs of extracting helium in a multipurpose processing facility at some future date from presently nondepleting gasfields are presented in Table B-1. This is the most probable configuration. The latest plant at Table Rock field, Wyoming, is this type. Thus, several natural resources are recovered simultaneously.

Based on preliminary calculations, tables B-2 and B-3 show the effect on break-even prices of natural gas and helium, respectively, if the plants were to be build for recovery of that single natural resource.

TABLE B-1 - Unit cost of products assuming fields will be produced for multiproduct sales

Nondepleting Field	CO_2	Sulfur	Natural Gas*	Helium
Tip Top	0	$10/LT	$1.60/Mcf	$ 4.50/Mcf
Lisbon	0	10/LT	0.60	11.00
So. Douglas Cr.	0	-----	0.80	14.30
Dineh bi Keyah	0	-----	1.80	18.80
Rudyard	0	-----	1.80	24.40
Clay Basin	0	-----	1.80	55.70
Church Buttes	0	10/LT	1.80	126.40

*Value $1.80/Mcf 960 Btu gas.

TABLE B-2 - Natural gas break-even prices assuming fields will be produced for only one product

Nondepleting Field	Production, MMcfy Natural Gas	Total Operating Cost, M$	Natural Gas 1/
Lisbon	6,480	$ 4,500	$0.70/Mcf
So. Douglas Cr.	3,672	3,600	1.00
Tip Top	31,570	57,100	1.80
Church Buttes	21,700	108,700	5.00
Clay Basin	432	3,200	7.30
Rudyard	382	4,200	11.10
Dineh bi Keyah	450	11,400	25.30

1/ Present value approximately $1.80/Mcf for 960 Btu/cu ft gas.

TABLE B-3 - Helium break-even prices assuming fields will be produced for only one product

Nondepleting Field	Production, MMcfy		Total Operating Cost, M$	Helium
	Natural Gas	Helium		
Dineh bi Keyah	450	562.3	$ 11,400	$ 20.30/Mcf
Rudyard	382	145.4	4,200	29.10
Lisbon	6,480	89	4,500	50.90
Tip Top	31,570	1,026	57,100	55.60
Clay Basin	432	42.8	3,200	73.80
So. Douglas Cr.	3,672	35.6	3,600	101.00
Church Buttes	21,700	538	108,700	202.10

APPENDIX C - Helium Price Histories

Table C-1
Wholesale Helium Price History

Year	Price/Mcf[1]	Production and/or Purification Facility[2]	Year Shut Down
1961	$35.0	Kerr-McGee Inc., Navajo, Arizona	1976
1962	35.0		
1963	35.0		
1964	35.0		
1965	35.0		
1966	30.0	Kansas Refined Helium, Otis, Kansas	----
		Alamo Chemical Co., Elkhart, Kansas	----
1967	26.0		
1968	25.0	Cities Service Cryogenics, Ulysses, Ka.	----
		Arizona Helium Co., Navajo, Arizona	1973
		Air Reduction Co., Teec Nos Pas, Ariz.	1969
		Navajo Tribe, Shiprock, New Mexico	1969
1969	21.5		
1970	21.0		
1971	21.0		
1972	21.0		
1973	23.0		
1974	23.0		
1975	26.0	Western Helium Corp.	----
1976	23.7		
1977	23.7	Linde Div., Union Carbide, Bushton, Ka.	----
1978	24.53[3]		

1/ 1961 through 1977 prices taken from MRI Draft Final Report, dated May 15, 1978, page 216.
2/ Companies listed under year of first production.
3/ This price calculated as an average of the prices for 1975 through 1977.

TABLE C-2 - Retail prices, f.o.b. destination, of Bureau helium sold by commercial suppliers, January 1977 through April 1978

Geographical Area	Northeast Coast	Southeast Coast	North Central	South Central	Northwest Coast	Southwest Coast
Gas: ($/Mcf)						
Cylinders						
1-9 cylinders						
High	82.50	101.00	120.00	110.00	71.50	123.00
Low	63.90	95.00	109.50	99.50	56.00	89.00
Average	73.20	98.00	114.70	104.70	63.70	106.00
Larger orders						
High	69.90		62.70		67.00	58.00
Low	60.20	84.38 1/	50.50	66.15 1/	51.70	50.00
Average	65.00		56.60		59.30	54.00
Trailers						
High			62.50			
Low	2/	48.64 1/	53.50	39.08 1/	53.20	48.14 1/
Average			58.00			
Liquid: ($/liter)						
Small orders						
1-5 50-liter dewars	N/A	N/A	N/A	6.28	N/A	N/A
1-5 100-liter dewars						
High	4.25	6.08	3.79	6.32	5.97	4.75
Low	3.50	5.89	3.75	5.45	3.64	2.76
Average	3.87	5.98	3.77	5.93	4.80	3.83
Large orders						
High	2.40 3/	4.08				
Low	2.00	3.39	1.50 4/	2.19	2.40	N/A
Average	2.20	3.73				

1/ Supplied directly from Bureau of Mines.
2/ Current prices to Brookhaven National Laboratory from Airco N/A.
3/ To Honeywell Radiation Laboratory from Airco.
4/ To Fermi National Accelerator Laboratory from Airco.

APPENDIX D

Authority of the Secretary of Interior with Regard to helium resources under the Helium Act Amendments of 1960.

	Authorizations	Helium Act Reference
1.	Acquire land - purchase, lease, gift, exchange, by eminent domain.	Sec. 3(a)(1)
2.	Make contracts - acquisition, processing, transportation, or conservation of helium, helium-bearing natural gas, or helium-gas mixtures.	Sec. 3(a)(2)
3.	Construct or purchase - plants and necessary equipment for the production, storage, purification, transportation, purchase, and sale of helium.	Sec. 3(a)(3)
4.	Reserves the ownership and rights to extract helium from any known gas bearing land on public domain not covered by Public Law 145, the Mineral Lands Leasing Act of 1920.	Sec. 3(b)
5.	Maintain and operate helium production facilities.	Sec. 4
6.	Supply Federal agencies helium demand.	Sec. 6(a)
7.	Establish price of Federal helium adequate to cover all costs.	Sec. 6(c)
8.	Establish and promulgate rules and regulations.	Sec. 11
9.	Assure future essential Government helium needs within economic limits.	Sec. 15

APPENDIX E
Recent Technology Changes

Helium production techniques are derived from a larger technology--the cryogenic fluid industry including such fluids as oxygen, nitrogen, hydrogen, argon, and liquefied natural gas. As this cryogenic technology advances and becomes more efficient, its application to helium production will reduce costs and consequently price. Some areas of recent advancement are the following:

Materials

Aluminum and stainless steel have replaced more expensive copper and brass as a construction material for cryogenic equipment.

Heat Exchangers

Plate fin exchangers assembled using mass production technology are being used in place of coiled tube and shell and shell and tube exchangers which are costly to construct, requiring a great deal of skilled labor.

Expansion Engines

Turbo expanders which are almost maintenance free in comparison with the older reciprocating machinery are now being used to generate refrigeration in cryogenic plants.

Compressors

Centrifugal compressors are in use in place of reciprocating compressors to compress the various plant streams. Lower investment and maintenance costs have resulted from this development.

Process Advances

Computerized data and calculations are available as well as new, more efficient process schemes to optimize the design of cryogenic processes so that helium plants built now and in the future will be designed to be more efficient than earlier plants.

The Linde Division of Union Carbide Corporation has developed a non-cryogenic helium purification process called pressure swing adsorption (PSA) which operates at about 300 pounds per square inch gauge and uses a proprietary adsorbent at room temperature. In this process, crude helium is passed through a series of adsorption beds to produce a product comparable to the high-purity helium offered for sale by the Bureau of Mines and other private helium production plants. There are two plants presently using the process, and an expansion of one has already been announced.

It is important to note that the PSA method begins with a crude helium product to feed the purification process. The PSA process is considered to be an impurity removal system which begins with a relatively high percentage of the product purified. It cannot be utilized as a crude separator which would begin with a very low concentration of the gas to be separated and purified. Thus, it cannot be used as a basic process to concentrate the low helium percentages found in natural gas. Also, the regenerating recycle crude helium stream from the adsorbers would of necessity need to be returned to a cryogenic crude helium plant for rejection of the impurities or possibly returned to a crude helium storage system.

A Canadian company is presently installing a completely automatic pilot plant to recover helium from natural gas using a membrane diffusion process. The unit being installed on a gas pipeline in Alberta may result in a completely new kind of helium plant.

Major cost reductions will come from application of advances to each facility and from multipurpose facilities, such as Btu improvement and liquefied natural gas (LNG) production.

APPENDIX F
Status of the Private Helium Industry

Helium Extraction Plants

Table F-1 gives information on the helium extraction plants in operation in the United States. Included are both private and Government plants. Phillips Petroleum Company's Dumas Helium Plant, which formerly sold crude helium to the Government under a contract for the purchase of helium for conservation is not listed, but it extracts helium along with other products from the gas stream and later returns the helium and some of the products to the stream to be marketed with natural gas.

TABLE F-1 - Helium extraction plants of the United States

Plant name	Plant owner	Plant location: County	Plant location: State	Company supplying gas	Gas source: Fields	Gas source: State	Remarks
Private:							
Greenwood plant	Gardner Cryogenics Corp. & Alamo Chemical Co.	Morton	Kansas	Colorado Interstate Gas Co. & Phillips Petroleum Co. (crude helium)	Greenwood Sparks	Kansas Kansas	Produces and sells pure helium in gaseous and liquid form.
Jayhawk Helium Plant	Cities Service Cryogenics & Cities Service Helex	Grant	Kansas	Cities Service Gas Co. & Sunflower Helium Plant (crude helium)	Hugoton Panoma Minor volumes from other small Kansas fields	Kansas Kansas	Produces crude and pure helium, some stored, some sold, some vented at Jayhawk.1/ Pure helium sold in gaseous and liquid form.
Kansas Refined Helium Co.	Kansas Refined Helium Co.	Rush	Kansas	Frontier Oil Co., Kansas-Nebraska Natural Gas Co., & Northern Helex Co. (crude helium)	27 small fields in central Kansas area		Produces and sells pure helium in gaseous and liquid form.
Northern Helex Co. Helium Plant	Northern Helex Co.	Ellsworth	Kansas	Northern Natural Gas Co.	Hugoton	Kansas & Okla	Produces crude helium for storage and for purification at Kansas Refined Helium Plant.
Sherman Helium Plant	Phillips Petroleum	Hansford	Texas	Phillips Petroleum Co.	Hugoton	Okla & Texas	Produces crude helium. Some is processed for purification at the Greenwood plant. Remainder is stored.
Sunflower Helium Plant	Cities Service Cryogenics & Kansas-Nebraska Natural Gas Co.	Scott	Kansas	Kansas-Nebraska Natural Gas Co.	Bradshaw Hugoton	Kansas Kansas	Produces crude helium for refining at Jayhawk plant.
Western Helium Plant	Western Helium Corp.	San Juan	New Mexico	Saguaro Oil Co.	Tocito N Table Mesa S	New Mexico New Mexico	Produces and sells pure helium. Not in production at present.
Government:							
Exell Helium Plant	U.S. Bureau of Mines	Moore	Texas	U.S. Bureau of Mines	Cliffside	Texas	Can produce pure helium; is not in production at present.
Keyes Helium Plant	U.S. Bureau of Mines	Cimarron	Okla	Colorado Interstate	Keyes	Oklahoma	Produces helium for storage and sale. Helium is also purified for redelivery under storage contracts.

1/ Crude helium released to the atmosphere after being separated from natural gas.

Production Capacity and Employment

Private helium production plants are producing helium for domestic and foreign markets. Only three of the six operating private helium plants produce pure helium. These three plants have a total design capacity of about 524 MMcfy of pure helium. The Linde Division helium purification plant addition to Northern Helex adds another 75 MMcfy to that total. Crude helium produced by private industry from former helium purchase contract plants is either purified for sale at one of the private helium purification plants; accepted by the Bureau for private storage and subsequent redelivery as crude helium or in pure form; or vented to the atmosphere. About 185 MMcfy of pure helium is redelivered to private industry from the Bureau of Mines Keyes Helium Plant.

The present private helium purification capacity will equal the private demand in 1983 and, at projected rates of natural gas production, the private helium demand will equal the annual helium supply available to private plants about 1996.

Table F-2 summarizes the private helium production capacity and employment.

Tables F-3 through F-8 detail the volume of helium available to operating private plants on an annual basis.

TABLE F-2 Summary of Private Helium Production Capacity and Employment
(All volumes in MMcfy at 14.7 psia & 70°F)

Plant	Plant Design Capacity		Natural Gas Reserves	Helium Reserves	Estimated Employment Related to Helium
	Crude	Pure			
Former Crude Helium Contractors					
Cities Service Helex	773		3,169,195	13,628	55
Northern Helex	798	75[2/]	3,011,545	11,035	57[3/]
Phillips Petroleum					
Dumas	656[1/]				
Sherman	607		452,176	3,165	7
National Helium Corp.	1,210[1/]				
Other Private Plants					
Alamo Chemical Corporation	168	168	79,609	442	25
Cities Service Cryogenics	203	203	944,840	4,460	12
Kansas Refined Helium	105	153	45,100	1,891	20
Western Helium Corp.	71[1/]	71[1/]			

1/ Plants not operating and not expected to restart.
2/ Linde purification addition to Helex.
3/ Includes 50 employees at Northern Helex and 7 at the Linde purification facility.

TABLE F-3 - Helium available to Cities Service Helex plant, 0.45%

(In MMcf)

14.70 PSI at 70 DEG F

1978	1979	1980	1981	1982	1983	1984
944.	922.	901.	880.	858.	837.	816.
1985	1986	1987	1988	1989	1990	1991
784.	753.	721.	690.	648.	606.	555.
1992	1993	1994	1995	1996	1997	1998
503.	451.	399.	347.	296.	244.	192.
1999	2000	2001	2002	2003	2004	2005
140.	88.	37.	16.	0.	0.	0.

TOTAL VOLUME = 13628.

TABLE F-4 - Helium available to Northern Helex plant, 0.43%

(In MMcf)

14.70 PSI at 70 DEG F

1978	1979	1980	1981	1982	1983	1984
721.	693.	662.	636.	615.	595.	578.
1985	1986	1987	1988	1989	1990	1991
560.	543.	527.	511.	496.	481.	466.
1992	1993	1994	1995	1996	1997	1998
453.	439.	426.	413.	406.	305.	203.
1999	2000	2001	2002	2003	2004	2005
152.	102.	51.	0.	0.	0.	0.

TOTAL VOLUME = 11035.

TABLE F-5 - Helium available to Phillips Sherman plant, 0.72%

(In MMcf)

14.70 PSI at 70 DEG F

1978	1979	1980	1981	1982	1983	1984
456.	344.	326.	298.	269.	203.	192.
1985	1986	1987	1988	1989	1990	1991
142.	132.	122.	112.	102.	91.	81.
1992	1993	1994	1995	1996	1997	1998
71.	61.	51.	41.	30.	20.	15.

TOTAL VOLUME = 3165.

TABLE F-6 - Helium available to Alamo Chemical plant, 0.57%

(In MMcf)

14.70 PSI at 70 DEG F

1978	1979	1980	1981	1982	1983	1984
92.	82.	73.	66.	60.	55.	13.

TOTAL VOLUME = 442.

TABLE F-7 - Helium available to Cities Service Cryogenics plant, 0.50%

(In MMcf)

-14.70 PSI at 70 DEG F

1978	1979	1980	1981	1982	1983	1984
258.	254.	251.	248.	246.	243.	242.
1985	1986	1987	1988	1989	1990	1991
240.	239.	236.	213.	194.	178.	164.
1992	1993	1994	1995	1996	1997	1998
150.	138.	128.	118.	111.	103.	95.
1999	2000	2001	2002	2003	2004	2005
89.	83.	79.	73.	69.	14.	5.

TOTAL VOLUME = 4460.

TABLE F-8 - Helium available to Kansas Refined Helium plant, 1.22%

(In MMcf)

-14.70 PSI at 70 DEG F

1978	1979	1980	1981	1982	1983	1984
538.	449.	360.	270.	181.	91.	2.

TOTAL VOLUME = 1891.

Table F-9
Known Special Market Relationships Between Helium Producers and Some of the Market Segments

Producer	User
Bureau of Mines	Section 6 (a) of the Helium Act provides: "The Department of Defense, the Atomic Energy Commission, and other agencies of the Federal Government, to the extent that supplies are readily available, shall purchase all major requirements of helium from the Secretary" (of the Interior). The Bureau of Mines has contractual agreements with 11 private companies to redeliver helium held for their account in storage, in crude or pure form. The private companies can then sell the helium on the private market.
Kansas Refined Helium Co., Inc.	The plant receives about 18 MMcf crude helium per month from Northern Helex Company via BOM storage to supplement its supply for pure production.
Greenwood Plant, operated by Alamo Chemical Co.	Phillips Petroleum Company's Sherman helium plant supplies crude helium to the Greenwood Plant for purification and is under contract to supply 20 MMcfy of helium to Liquid Carbonics Corp. Gardner Cryogenics handles all marketing of pure helium for Phillips Petroleum Company.
Northern Helex Company	The majority of crude helium stored for private company accounts is produced by Northern Helex Co. The Linde Division helium purification addition to the Helex plant requires about 75 MMcfy of the Northern Helex Company's helium plant production. Linde has announced plans to build another purification addition with a capacity of about 300 MMcfy.

APPENDIX G

Bureau of Mines and Private Industry Helium Transporatation Operations

The Bureau of Mines transports about 40 percent of its helium sales to Federal users in tank cars, about 6 percent in small cylinders, another 24-30 percent is transported by Bureau-owned helium trailers, and the rest is transported by commercial helium trailers. A small volume is transported as a liquid in dewars.

It is estimated that approximately 30 MMcf (or about half) of the total private helium trailer capacity is owned and controlled by Jack B. Kelley Company. This company also owns about 1,200 (or about 10 percent) of the private industry small cylinder inventory and has at least four bulk liquid helium transport vessels. The remainder of the private helium transportation equipment is owned and controlled by Airco, Linde, Gardner Cryogenics, and numerous smaller companies.

The present quality control and certification program carried out at government plants assures government users that the helium they receive meets their specifications. To a large degree, the success of the quality control program is attributed to government control of its own shipping containers which are only used for transport of high-purity helium. Federal agency purchases of private helium could require government control at each private producer loading site to monitor all shipments going to Federal users.

Table G-1 estimates the current status of helium transportation equipment owned and controlled by the Bureau of Mines and private industry.